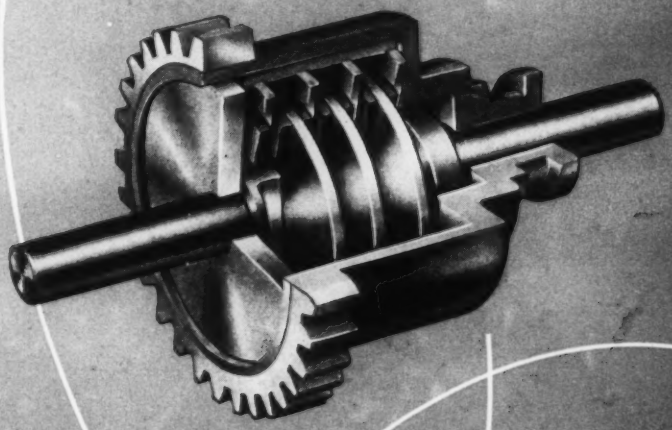
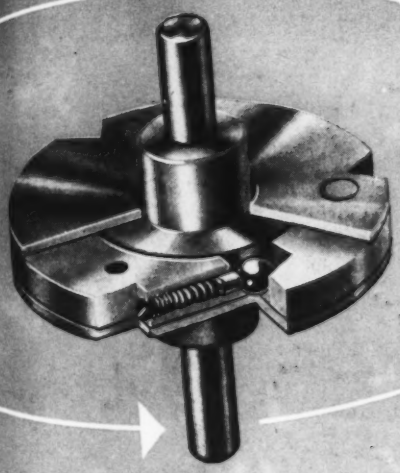
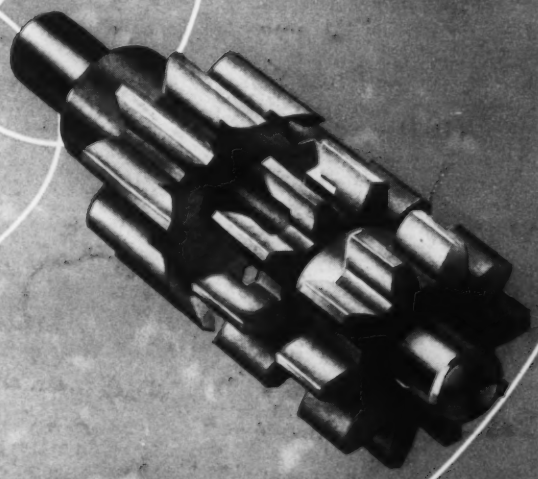
OCTOBER 18, 1956
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION







Miniature Clutches

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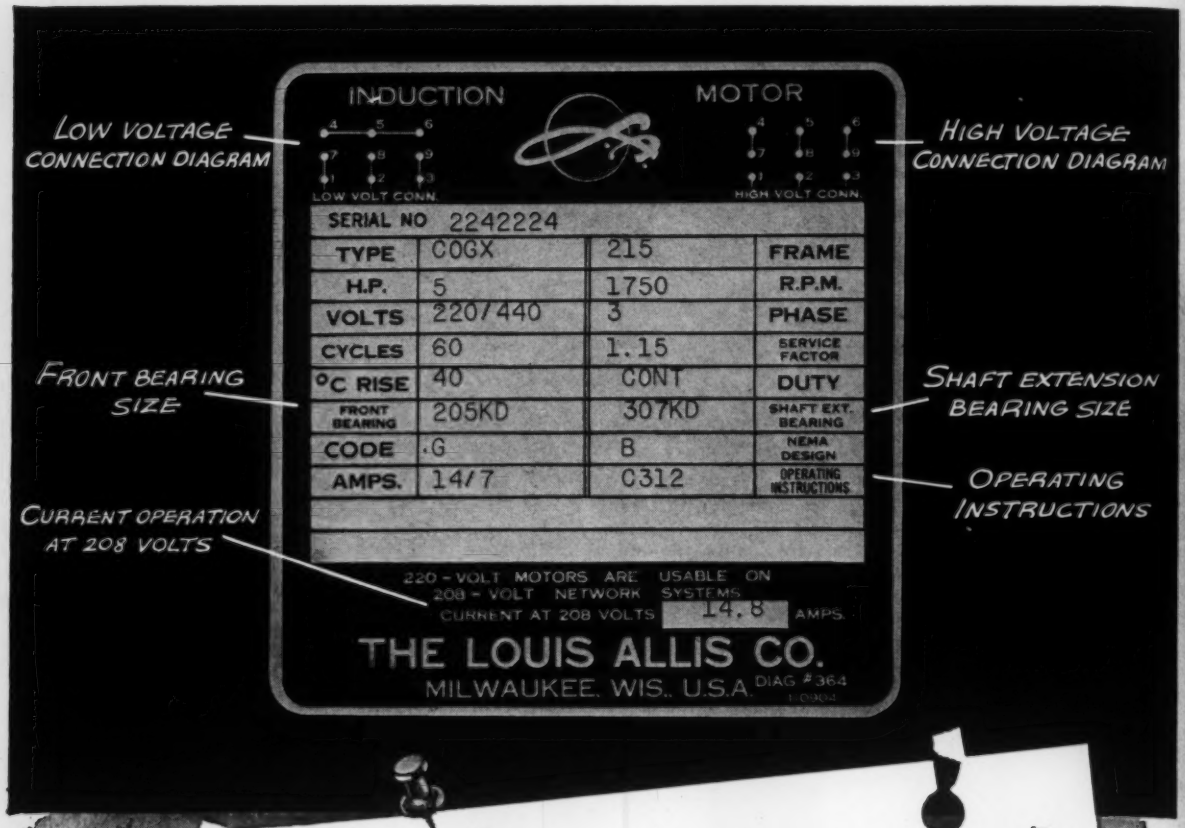

LOW VOLTAGE CONNECTION DIAGRAM
INDUCTION MOTOR
LOW VOLT CONN.
HIGH VOLT CONN.
HIGH VOLTAGE CONNECTION DIAGRAM
SERIAL NO 2242224
TYPE COGX 215 FRAME
H.P. 5 1750 R.P.M.
VOLTS 220/440 3 PHASE
CYCLES 60 1.15 SERVICE FACTOR
°C RISE 40 CONT DUTY
FRONT BEARING 205KD 307KD SHAFT EXT. BEARING
CODE G B NEMA DESIGN
AMPS. 14/7 C312 OPERATING INSTRUCTIONS
FRONT BEARING SIZE
SHAFT EXTENSION BEARING SIZE
CURRENT OPERATION AT 208 VOLTS
OPERATING INSTRUCTIONS
220 - VOLT MOTORS ARE USABLE ON 208 - VOLT NETWORK SYSTEMS
CURRENT AT 208 VOLTS 14.8 AMPS.
THE LOUIS ALLIS CO.
MILWAUKEE, WIS., U.S.A. DIAG #364

why is this nameplate important to you?

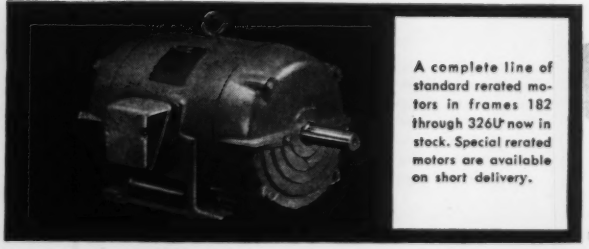
It provides visible evidence that Louis Allis standard motors are built with special care to run better, last longer . . .

Look at the information on this nameplate—information that makes life a lot easier for the user. And to keep this information available at all times, we make this nameplate out of corrosion-resistant stainless steel.

Yes, in the new LA line of standard motors, even the nameplate gets special attention from our engineers. And here's what it means to you:

- The rerated frame size shown means more horsepower from motors with smaller outside dimensions. Performance has been improved by new materials and manufacturing methods.
- Spare bearings can be easily ordered from bearing size and type designations on nameplate, thus eliminating disassembly of motor to determine bearing size. Bearings used are conservatively rated for long life.
- No more lost connection diagram since this information is simply and clearly shown on nameplate. This combined with permanent lead markings, assures that correct motor connections can always be made.
- 220/440 volt motors are suitable for operation on 208 volt systems and full load current for 208 volt operation is included on the nameplate. This eliminates need for original equipment manufacturers to carry a stock of 208 volt motors.

Because they are built with special care, new LA standard motors can do a lot more for you. New bulletin No. 1700 shows you why—just write for your copy.



A complete line of standard rerated motors in frames 182 through 326U now in stock. Special rerated motors are available on short delivery.

LA-106

THE LOUIS ALLIS CO.
MILWAUKEE 7, WISCONSIN

Circle 501 on page 19

In just .02 of a second the Ross Comet II completes a valving cycle—both energizing and de-energizing! This solenoid operated, balanced spool, 4-way is light and compact. Built to JIC standards, the ¼" or ⅜" Comet II converts to scores of different uses!

Write for bulletin 314.

Ross

• • • EnginAIRed Circuitry • • •

OPERATING VALVE COMPANY

109 E. GOLDEN GATE AVE. • DETROIT 3, MICHIGAN

Circle 504 on page 19

GOODYEAR INDUSTRIAL PRODUCTS
GTM-Specified
Torsional rubber spring for Truck and Tractor Seats
1. Special, tough rubber compound to withstand constant torque
2. Strong rubber-to-metal bonds
3. Top Plate Assembly
4. Base Plate Assembly
5. Flanged Bearing

G.T.M. helps give "passenger car" ride to trucks and tractors

A "PASSENGER CAR" ride from trucks and tractors is now possible with a new type of seat which embodies a unique suspension system.

Heart of this system is a set of torsional rubber springs developed with the close help of the G.T.M. —Goodyear Technical Man. These husky cylinders of rubber are especially compounded and precision-molded, then mounted under torsion to level out vibrations *five times as effectively* as conventional springs. Moreover, they have proved to be unaffected by climatic changes and *as durable as the vehicles on which they are installed.*

The G.T.M. was consulted on this particular problem because of his broad experience in getting the most out of molded rubber in virtually any industrial application. Whether your problem involves torsional rubber springs or engine mounts or gaskets or rolls or bumpers or diaphragms or something completely new, you'll find it pays to talk to the G.T.M. It's easily done by writing Goodyear, Industrial Products Division, St. Marys, Ohio, or Akron 16, Ohio.

MOLDED GOODS by

GOODYEAR

THE GREATEST NAME IN RUBBER

IT'S SMART TO DO BUSINESS *with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."*

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

October 18, 1956
Volume 28—No. 21

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Bob Rossi, Chief Engineer, tells
Roy Johnson, Plant Manager

"We switched to Formbrite —and saved 12 cents apiece!"

.032" gage 70-30 Formbrite is used for this 4½" diameter rearview mirror head shown full size. Strip is $5\frac{13}{32}$" wide supplied in heavy coils for long press runs. Copper, nickel and chromium plating on a solid brass base provides a bright, rustless, long-lasting outdoor finish.

Peerless Rearview Mirrors. "Flight-Wing," below, and the newer "Director" model, left. Housings and mounts are chromium-plated zinc-base die castings.

This easy-to-polish, superfine-grain drawing brass has been slashing finishing costs in plant after plant, on all kinds of jobs. Now Peerless Accessories Co., of Mount Holly, N. J., reports:

"To our line of lighting and safety automotive accessories, we've recently added two rearview mirror assemblies. We had been using regular drawing brass for the dished head until your representative persuaded us to try Formbrite. Here are the results, based on a very careful cost study:

Finishing procedure using regular drawing brass	Present procedure using Formbrite®
1) Grease grinding or "cutting"	Not necessary with Formbrite
2) Buffing	Light buff
3) Copper strike	Copper strike
4) Nickel plate (.00045")	Bright nickel plate (.0003")*
5) Buffing nickel	Not necessary
6) Chromium plate	Chromium plate
Cost 27¢ each	**Cost 15¢ each**

"That's a saving of 12 cents apiece. Multiply it by 3,000 to 4,000 a day and it becomes important money!"

*Formbrite's superfine grain made possible a lighter but equally serviceable plate of *bright* nickel

Surprisingly, Formbrite doesn't cost a penny more. Find out for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you make a better product at lower cost. Write for Publication B-39. Better yet, ask us about a sample lot. The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 5670

Formbrite FINE-GRAIN DRAWING BRASS

an ANACONDA® product
made by The American Brass Company

Circle 506 on page 19

Engineering News Roundup

Photos Show Source of Unburned Fuel in Engines

NEW HAVEN, CONN.—A "thin skin" of unburned fuel around the walls of an automotive engine's combustion chamber has been observed photographically by General Motors Research Staff engineers.

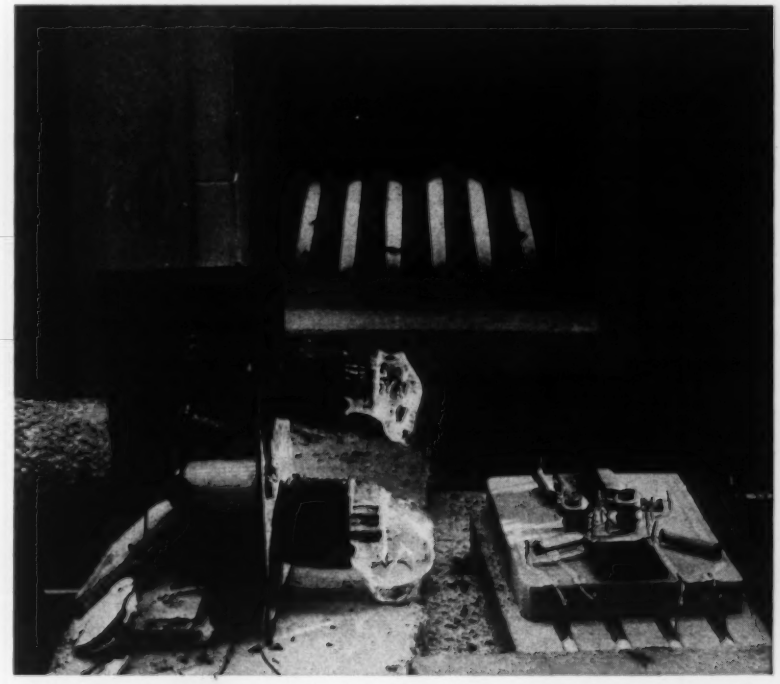
Reporting before the 6th International Symposium on Combustion at Yale University, Wayne A. Daniel of GM Research Staff's Fuels and Lubricants department said that although engineers have known for 20 years that a small portion of fuel passes unburned through an engine, its source had not been established.

He said this "thin skin" or "quench zone"—0.002 to 0.015-in. thick—appeared in photos of a small segment of the combustion chamber wall. The photos were taken through a transparent quartz window in the head of a laboratory test engine.

They showed that when the air-fuel mixture is ignited, the flame fans across the combustion chamber until it almost touches the relatively cool chamber walls. Next to the walls the mixture does not burn.

This "quench zone" was observed even when the engine was operating under accelerating and cruising conditions, when concentrations of unburned hydrocarbons were less than 5 per cent. Earlier studies had indicated a much higher concentration of unburned fuel passes through an automotive engine when it is decelerating.

Commenting on the findings, Mr. Daniel estimated that only one-third of the portion of Los Angeles smog caused by hydrocarbons is released by cars during deceleration and two-thirds is the 5 per cent in engines left unburned during acceleration and cruising.



New electronic components developed by GE, at right, demonstrate ability to withstand 1500 F temperature which destroys conventional equipment, at left. Laboratory models of the new components are capable of operating under conditions to be encountered in high-speed aircraft and missiles. Weight savings are design objectives in using the new control elements since vehicles need not carry cooling apparatus.

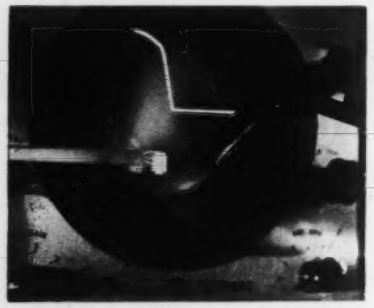
New Electronic Components Work at High Temperatures

NEW YORK, N. Y.—The penetration of a critical temperature barrier in the development of guided missiles and supersonic aircraft was demonstrated recently when General Electric scientists exhibited laboratory models of electronic devices and circuits that operated literally "red hot." The demonstration indicated that a major step had been taken toward overcoming the inability of electronic controls to withstand the intense heat generated by air friction at extreme speeds.

An additional feature of the new electronic circuits is their ability to operate for long periods while exposed to intense nuclear radiation.

Advantages in using the new components for missiles and aircraft are extensive weight reductions made possible by eliminating bulky cooling equipment.

Inside electric furnaces and under the heat of blowtorches, new vacuum tubes, capacitors, resistors, transformers, inductors, wires, printed circuit boards and an electric motor were operated at temperatures ranging from 900 to 1500 F. Metals such as titanium and special ceramics made the high



Laboratory model of new G-E microminiature ceramic vacuum tube operates, as indicated on the oscillograph in the background, even when red-hot in the flame of a blowtorch.

temperature performance possible.

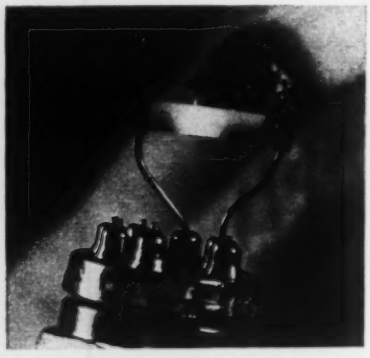
It was also announced by GE that similar electronic assemblies have been operated at high temperature for more than 1000 hr in the neutron flux of the graphite reactor at the Oak Ridge National Laboratory.

The overall reliability limit in much of present-day equipment is about 200 F. The recent emphasis on guided missiles and supersonic aircraft has greatly increased the requirements, but until now extensive research and expenditure has produced only a few components capable of operation at 500 to 600 F.

To help show the versatility of the high-temperature electronic components, laboratory scientists demonstrated a phonograph operating with the amplifier glowing in an oven at 1500 F. Another circuit was shown that picked up and amplified a radio signal even while the equipment was in the direct flame of three blowtorches.

Other significant demonstrations included two multivibrator (electronic pulsing) circuits operating in electric ovens at temperatures ranging from 1000 to 1500 F. Both of these demonstrations involved circuits using vacuum tubes, resistors, capacitors, and printboards. One demonstration featured "heaterless" tubes which at high temperatures do not need the power supply normally required to heat the filaments in conventional vacuum tubes.

In another demonstration a new high-temperature transformer was shown operating in an oven at nearly 1000 F.



Glowing-hot resistor of titanium and ceramic construction operates at temperature far more than needed to light a cigarette. The part is one of many new components developed especially for high-temperature performance.

More Engineers Overseas May Work on U. S. Projects

NEW YORK, N. Y.—The recruiting of engineers abroad is one method some American companies have been using to fill their needs for technical employees. An extension of the idea, now to receive increased emphasis, is the export of projects instead of the import of labor.

The plan will be promoted by the Franco-American Research Corp. which would operate as a liaison unit and has arranged with leading research and development concerns in France to accept projects originating in the U. S. Franco - American claims that modern methods of communication overcome the barrier of distance, and other advantages are that the engineers need not move and learn a new language.

Certain American companies, however, reserve endorsement of the plan due to the absence of sufficient international standardization. Extensive conversions from the metric system and from European standards for screw threads and gears would be necessary. European engineers would also have to learn to think in terms of assembly line manufacturing.

Radar Speed Meter Photos, Flags Violators

CHICAGO, ILL. — A radar speed meter which operates only when speed violations are committed has been developed by Admiral Corp.

The new meter can be adjusted for any speed from 25 mph up to the highest limits, making it adaptable for use in city zones as well as on the open highway. It operates only when vehicles, passing in either direction, exceed the set limit.

A switch on the meter can be used, if desired, to hold a speed

reading up to two minutes, so a traffic officer doesn't have to keep the meter under constant observation. When the speed has been read, the switch can be manually released.

An optional camera attachment will take a motion picture record, by split image photography, of both the car's license number and the speed reading on the meter. Flood lights can be synchronized to operate automatically with the meter for night photography.

Another optional feature is a tape recorder attachment which will record the speed reading, the

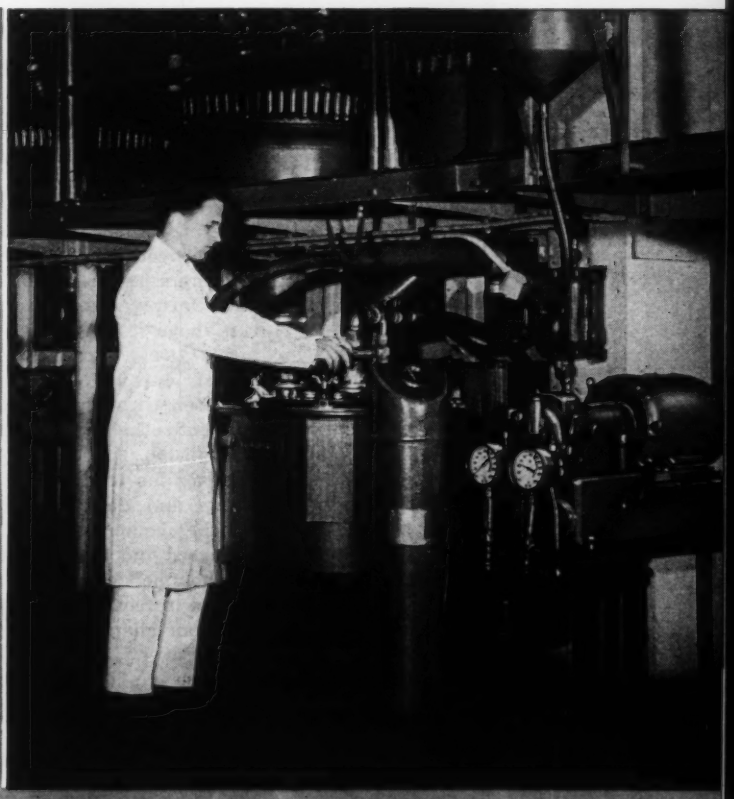
Front Cover

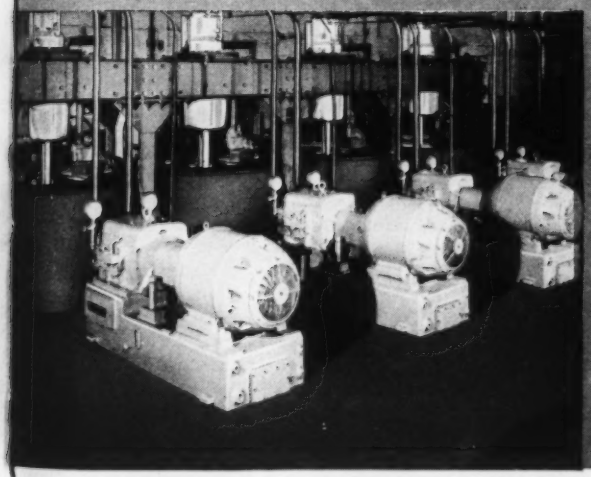
As George Farnsworth's front cover emphasizes, all clutches have one basic function: to connect and disconnect two shafts or rotating members. But the problems in designing and manufacturing miniature clutches are rather specialized. "Hank" Lundquist's article on Page 124 gives the facts for a number of basic types.

Any speed for you too!

Unique Oilgear Fluid Power "ANY-SPEED" Drives establish new production and economy records

Any desired speed from zero to maximum . . . any rate of acceleration . . . any rate of deceleration . . . any rate of hydrodynamic braking . . . any speed adjustment between operations . . . synchronization of two or more drives . . . direct or remote precision speed control irrespective of load, input power or oil viscosity changes . . . all with Oilgear Fluid Power "Any-Speed" Drives. Old and new users name them *"the drives"* for their heavy-duty needs. You probably didn't know this! Every day, people are equally surprised—*and far more amazed when they know the facts.* Write and get them *now*. THE OILGEAR COMPANY, 1568 W. Pierce Street, Milwaukee 4, Wisconsin.





This Centrifuge at Abbott Laboratories

Leading house in pharmaceutical, drug and chemical field, Abbott Laboratories installed first Oilgear Drive on Tolhurst centrifuge in production department. Experience was so satisfactory it led to the inclusion of another Oilgear equipped Tolhurst centrifuge in their experimental laboratories.

SPECIFICATIONS: Speed continuously variable from zero to 1200 rpm max. (in this case). Full control of acceleration/deceleration speed and rate. Permits that infinitely modifiable speed best suited to loading, washing, spinning and unloading.

Photo Courtesy, Chemical Processing Magazine

This Centrifuge at powder plant in east

In a somewhat different application, these 4 Oilgear 60 hp "Any-Speed" Drives serve Tolhurst centrifuges in powder plant in the east. Centrifuge accelerates to 300 rpm for loading, to 900 rpm for 15-minute centrifuging, then decelerates to 70 rpm for "plowing." Unloading is automatic.

Tolhurst is a division of American Machine & Metals, Inc.

OILGEAR
Fluid Power

PIONEERS . . . NOW THREE PLANTS FOR FLUID POWER

Circle 507 on page 19

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES

XUM

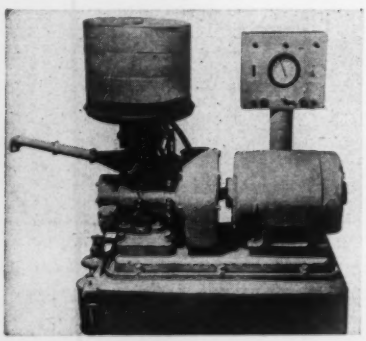
traffic officer's verbal description of the car and driver, a reading of the license number, and the date and time of violation.

The meter also can be synchronized to remote portable traffic light especially set up to stop a speeding car at locations and in traffic conditions where it is practical to do so. When the meter registers a speed violation it automatically changes the traffic light from green to amber to red. The equipment can be set up by one man and be ready for operation in less than two minutes.

Compact Gas Liquefier Has Multiple Pistons, One Cylinder

MOUNT VERNON, N. Y.—A new gas liquefier of simple design and small size produces liquid air at the touch of a button in a matter of minutes. Introduced by the Instruments Div. of North American Philips Co. Inc., the new liquefier is 37 in. long, 20 in. wide and 34 in. high. It produces approximately 5 qt of liquid air per hour.

Air or gas to be liquefied does not pass through the internal mechanism of the machine. Instead, it enters a chamber surrounding the refrigerating cylinder at normal atmospheric pressure, condensing on the cold surface of the head until the quantity is large enough to be run off. The system provides an oil-free, high-purity product.

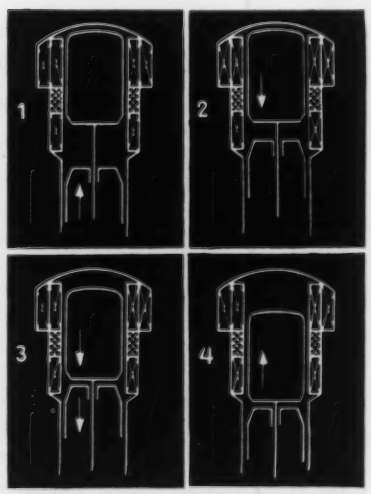


Small-size liquefier occupies space of an office desk, generates 5 qt liquid air per hr. Cylindrical chamber at top is ice separator.

The machine consists of a single cylinder containing two pistons, properly phased and actuated from two throws on the same crankshaft. The rod for the upper piston (called the displacer) slides through the center of the lower piston and the crankshaft is arranged so a phase difference of less than 90 degrees is maintained.

At one point of the cycle, the lower piston and the displacer come close together, compressing the gas between them. As the helium is compressed the displacer moves downward to enlarge the chamber above it. At the proper moment, the compressed helium is forced out of the compression chamber through the regenerator and into the expansion chamber where cooling takes place.

Next, due to the phasing of the piston and displacer, the volume of the compression chamber is increased and the expansion chamber volume decreased. Thus, the helium is moved back to the compression chamber without being compressed. Action on the gas during complete cycles can be described as: Compress—Transfer, Expand—Transfer. The success of the design depends on the ability to move helium back to the compression chamber at essentially constant volume after the com-



Operation of the liquefier occurs in four phases: compress, transfer, expand, transfer. Air liquefies on contact with outer condenser surface.

Topics

A handier grenade, the size, weight and shape of a baseball, has been patented. The weapon is said to be lethal within a 15-ft radius but harmless 60 ft away, the distance an average serviceman can throw it.

• • •

New finishing process for colored and natural-finish aluminum sheets and extruded shapes gives the effect of a continually changing, sparkling surface pattern. Alcoa achieves this decorative finish by etching a special large-grained aluminum alloy to bring out tiny reflecting facets.

• • •

High flying by an Air Force pilot in a Bell X-2 rocket plane has reportedly broken the manned-flight altitude record of 90,000 ft. The flight was made at a rate of speed under 1900 mph, a record also set by the X-2.

• • •

A plastic balloon broke another altitude record by climbing to 141,000 ft—21,000 ft higher than any previous balloon has gone. About 65 ft in diameter, the sphere has walls one-fourth the thickness of those in previous balloons.

• • •

Gas-turbine dream bus, capable of cruising at 125 mph, is designed with a plastic body, polarized glass roof, four-wheel suspension, individual armchair-type seats and built-in refrigerator, coffee machine and buffet. Such a bus, according to the Italian Viberti Motor Co., will be produced as soon as roads are built that will accommodate it.

• • •

Transatlantic telephoning is no longer dependent on successful transmission of radio waves. The first telephone cable linking the U. S. and Europe was put into use a few weeks ago. The cable, laid at a cost of $42 million, can carry 36 conversations simultaneously.

• • •

Flying crane-type helicopter will be the goal of a design study undertaken by Vertol Aircraft Corp. under an Army contract. A craft capable of carrying 16 tons of military equipment up to 100 miles is sought for use where terrain prevents land transportation.

Circle 508 on page 19→

Yours.. for the asking

The proper material for sintered bronze or iron bearings has always been a major problem to design men. Now for the first time a chart has been engineered, clearly showing the complete chemical, mechanical, and work characteristics of a wide range of sintered bearing materials. The best material for most applications can be selected by a draftsman in a matter of minutes. Only requests on company stationary will be honored.

BOUND BROOK

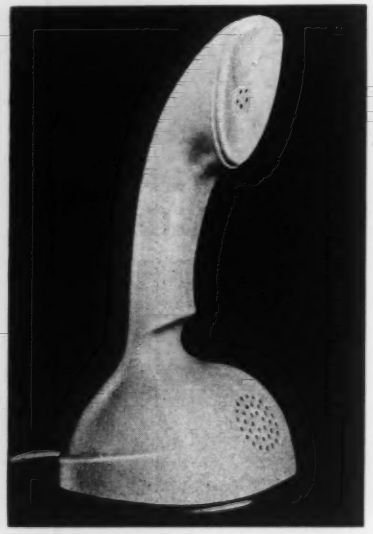
BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

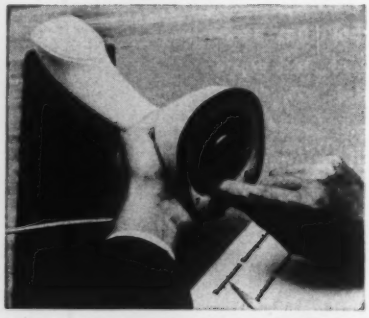
POWDER METALLURGY BEARINGS + PARTS

pression and expansion strokes.

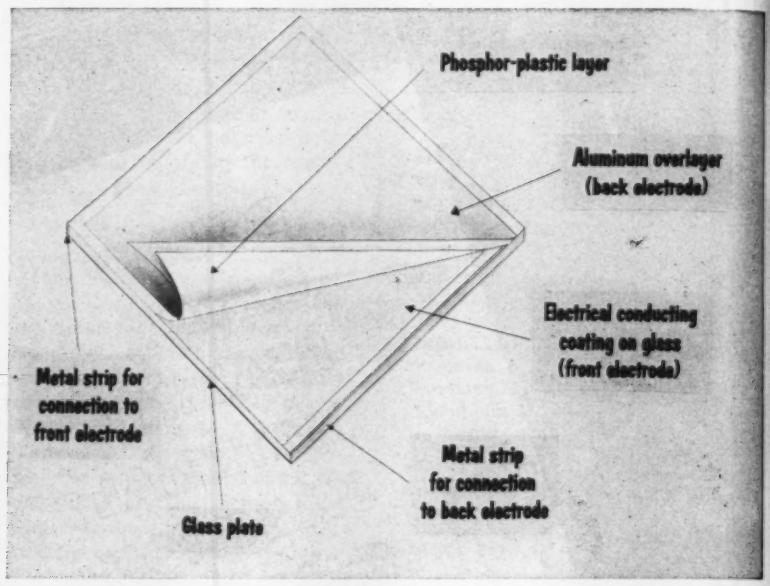
The machine is driven by a 10-hp motor connected to the machine through a flywheel, clutch and ratchet. The ratchet prevents the machine from running backward if electric power is cut off. The machine stops automatically if helium pressure exceeds 375 psi or drops below 220 psi.



LOOK MA, NO HANDS are needed to support the Ericofon, a telephone of unconventional design. The instrument, introduced by North Electric Co., stands 9¼ in. high on a 4½ by 3⅞-in. base. It is molded in one of six colors of thermoplastic material. The receiver is permanently sealed inside the upper part of the case, and the transmitter is in the inside lower front part of the base.



DIAL IS IN THE UNDERSIDE of the telephone's base. In the center of the dial is a "Standswitch," which releases to connect the line when the Ericofon is lifted and disconnects it when the instrument is replaced on its base.


Phosphor-plastic layer
Aluminum overlayer (back electrode)
Electrical conducting coating on glass (front electrode)
Metal strip for connection to front electrode
Metal strip for connection to back electrode
Glass plate

Electroluminescent panels used to light a room have sandwich-like construction. Glass plate is coated with transparent, electrically conducting film and a layer of phosphor-plastic. Topping is aluminum.

Wall Panels Light Room By Electroluminescence

PITTSBURGH, PA.—Area lighting by electroluminescence was demonstrated recently by Westinghouse in a room built into its recently dedicated new research laboratories. Electroluminescent glass panels 1 ft square line the ceiling and three sides of the room. Light given off measures 50 ft-candles, equivalent to that in a well-lighted office or class room.

The panels are sandwich-like in construction. Glass plates ⅛-in. thick are coated with a transparent, electrically-conducting film. Over this is spread a thin layer of polyvinyl chloride plastic in which is embedded a zinc sulphide type phosphor. The top layer is an aluminum conducting coating. A panel thus resembles a capacitor, with two conducting layers separated by a dielectric.

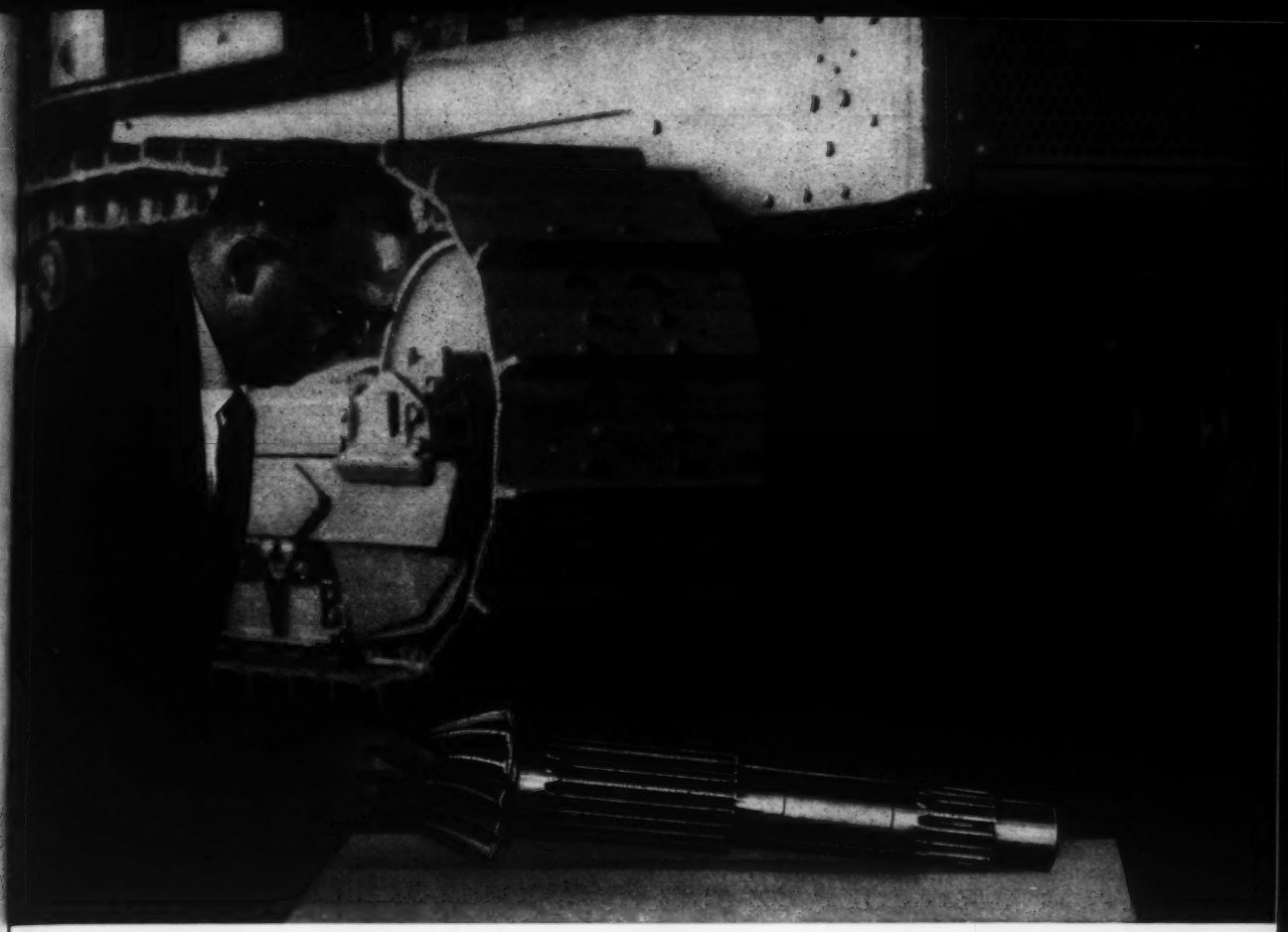
Electricity applied is 350-v, 3000-cycle ac. Brightness of the panels is 100 ft-lamberts and efficiency is 3 lumens per watt.

The brightness of electroluminescence is proportional to both the frequency and voltage of the electricity applied. Raising either one increases the brightness. Thus, 2000 ft-lamberts is obtained by using a 600-v, 20,000-cycle ac power source. Raising the voltage too much causes problems such as dielectric breakdown.

Due to the fact that some phosphors have more than one emission band, frequency can affect the color emitted. One phosphor glows green when power below a frequency of 1000 cycles is applied. Above 5000 cycles, the light emitted is blue. In between it is varying shades of blue-green. The color white is obtained by mixing together red, blue, and green phosphors.

A home of the future may have two control knobs in every room, one for brightness and the other for color. Like the volume knob on a radio, these will adjust for any level of brightness, and could create color atmosphere varying in shades of white, to blue or red.

Unlike brightness, present peak efficiency of 9 lumens per watt is achieved by using electricity of only a few hundred cycles and a few hundred volts. Applying higher or lower values only decreases the efficiency. Present incandes-



Caterpillar Tractor Co. Metallurgist T. H. Spencer inspects final drive pinion for D9 crawler tractor weighing 28 tons. Severe loading of this large pinion requires a steel with high case and core hardenability. Several years ago Caterpillar Tractor Co. found that simply by increasing the molybdenum content of AISI 8622 (to 0.30-0.40%), the desired properties were obtained at lower cost than was possible in any of the standard carburizing grades.

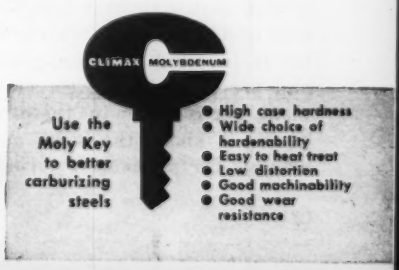
Caterpillar Tractor Co. improves case and core hardenability of carburizing steel by increasing molybdenum content

"Drive pinions in tractors must take very high torque loads," says T. H. Spencer, Metallurgist for Caterpillar Tractor Co. "AISI 8622 steel, which we had been using, couldn't give us the hard case and strong, tough core we needed in these heavy sections. Other standard carburizing steels with the requisite properties would have cost substantially more. We found, however, that we could achieve the desired surface and core properties by simply modifying AISI 8622 with a higher percentage of molybdenum. We have been using this composition for several years, and results have been excellent."

Caterpillar Tractor Co.'s experience shows how increasing molybdenum in a carburizing steel helped to solve a specific problem. Perhaps your product, too, can benefit by higher molybdenum content.

A technical article, "New Carburizing Steels for Critical Gearing", describes some recent investigations of higher-moly carburizing steels. For a reprint, write Climax Molybdenum Company, Dept. 11, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM



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SOON TO TRY RECORD-LENGTH WINGS, the first of Lockheed's new Super Constellations, Model 1649A, was recently towed from its assembly hangar. The 150-ft wings are 27 ft longer and one-sixth thinner than those of previous Super Constellations and will hold fuel for 6300 miles without consuming reserves. Extra-broad propellers measure 16 ft, 10 in. and turn at slow speed. Gross takeoff weight is 156,000 lb. Four Wright turbo-compound engines, each developing 3400 hp, will drive the plane at 350 mph.

cent efficiency at 100 w is 16 lumens per watt and fluorescent efficiency at 40 w is 60 to 70. Likely maximum future efficiencies are: electroluminescence, 240; incandescence, 22; fluorescent, 100.

Study Indicates Value of Production Worker's Equipment

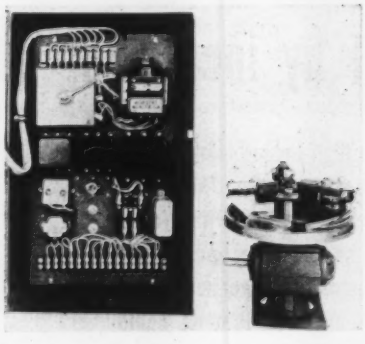
CHICAGO, ILL.—The average American production worker today uses $12,500 worth of equipment in his job, according to a study made by the Council for Technological Advancement. The study compares the amount of capital invested per production worker in 1952 and 1939. Representative industries and investment per worker for those two years are:

Industry	1952	1939
Fabricated metal products (including ordnance)	$7718	....
Electrical machinery	10,285	$4627
Machinery, except electrical	11,333	7396
Automobiles	15,064	6490
Other transportation equipment	8338	8331
Instruments and related products	10,267	....
Average, all industries	11,980	6205

The recently published report also indicates that almost 40 per cent of U. S. manufacturing capital is invested in metal-products and processes industries. Investment per worker in these categories is about the same as the average for all manufacturing.

Magnetic Unit Controls Continuous Process Lines

WELLESLEY HILLS, MASS.—A magnetic memory system has been especially designed for delayed control of high-speed continuous process lines and automatic sorting of items moving through complex conveyor systems. Developed by Automation Inc. and named Magdelay, the system is applicable to lines using sheet metal, wire,



tubing, plastic, paper or textiles where automatic measurements can be employed to control subsequent operations.

In cardboard strip, for example, a photocell might be used to detect off-color areas. Thereafter the strip is printed and then cut for carton blanks. Magdelay will remember the location of every defective area and then cause a sorting mechanism to pull out all defective blanks. In warehousing operations and food processing plants, Magdelay can control automatic switching of packages or items to two or more destinations.

In Magdelay systems, the measurements to be remembered are converted to magnetic signals on narrow sectors of a hardened steel disk. The disk rotates in synchronism with the processing or conveyor line. The measurements are then read off the disk at the same time that the material that was measured reaches the action or sorting points. The read-out is accomplished no matter how fast the line is moving. After read-out the disk is erased and is ready for reuse.

Magdelay systems accept signals from almost all measuring devices, including photoelectric controls, pressure switches, relays, beta gages, ultrasonic detectors and magnetic detectors. The systems are insensitive to process or conveyor line speeds. No exact gearing or coupling ratio need be prescribed between the processing or conveyor line drive shaft and the Magdelay input shaft. Any number of measurement stations may be added on a procession or conveyor line. Either one or two action or sorting stations may be

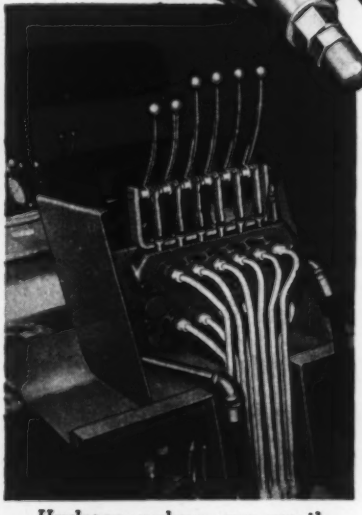
7 OUT OF 9 BUILDERS OF BACKHOE DIGGERS USE HYDRECO® HOLLOW-PLUNGER VALVES

Why is it so important *to YOU* that 7 out of 9 builders of Backhoe Diggers use HYDRECO Hollow-Plunger Control Valves? Analyze the functions involved in this Fluid Power application, and the answer is clear. Here is a rugged service application requiring multiple manual control of Fluid Power operations, good throttling, and easy-to-reach controls. All these features are combined in Hydreco Hollow-Plunger Valves to give the operator a feeling of "playing" the machine.

Hydreco Hollow-Plunger valves are perfect for this application. Check valves built into the plungers absolutely prevent back flow and cross flow between cylinders, therefore rapid sequence of operations is possible on multiple cylinder machines.

The Hydreco valve enables the operator to level, dig, hoist, swing and dump quickly and easily. The operator has the touch he needs to get the best out of a good machine, day in and day out. That's why operators like Hydreco Hollow-Plunger Valves.

Designers like Hydreco valves too, because with all components built in, they come smaller and fit into tight places more easily. For smoother operation, for more work at less cost — apply HYDRECO Hollow-Plunger Valves to your multiple-function equipment!



Hydreco valves are available with up to 6 plungers.

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Kindly send me full information on Hydreco Hollow-Plunger Control Valves.

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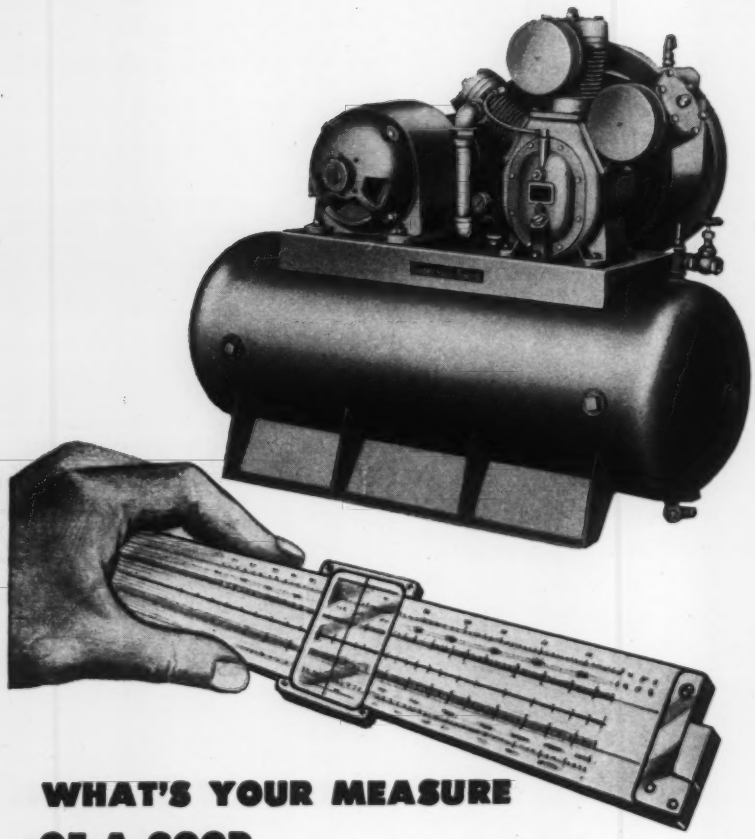

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Size for size—feature for feature—you'll do well to compare the many advantages the Ingersoll-Rand Air Compressor offers your product:

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- Outlives other compressors—years longer than most as the record shows.
- Looks like Quality—and it is—compact, well constructed, durably built.

Get more detailed information on I-R Air Compressors—½ to 20 hp—and see how they can help the sale of your own equipment. For prompt response, write to:

Ingersoll-Rand

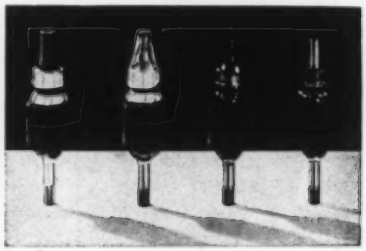
3-351 11 Broadway, New York 4, N. Y.

accommodated with Magdelay model 1000. Power failures do not disturb measurements already recorded.

Plastic Seals Simplify Armature Finishing

CHICAGO, ILL.—A new method of masking armature bearing surfaces before the varnish dip uses cellulose seal caps similar to those on wine and liquor bottles. The caps replace conventional masking tape.

The new procedure, followed by the Portable Electric Tools Co. Inc., consists of the four steps illustrated: armature bearing is



covered with oil-soaked, snug-fitting reused paperboard core; solution-wet cellulose cap is placed over commutator and bearing surface; cap quickly dries and shrinks to durable, skin-tight seal and the assembly is varnish-dipped; when varnish dries, seal is peeled off and the core is removed.

The seals are the products of the Celon Co. They can be imprinted and are available in colors, opaque or transparent.

Plans To Be Drawn for Reactor-Powered Tanker

LONG ISLAND CITY, N. Y.—A contract to study the feasibility of building a closed-cycle, gas-cooled power reactor by 1961 to propel an oil tanker has been awarded to the Ford Instrument Co. by the Atomic Energy Commission. The nuclear-powered main propulsion system would be installed in a 707-ft long supertanker with a capacity of 38,000 tons dead weight.

In addition to the reactor itself,

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Ford Instrument Co. will design or specify all nuclear instrumentation and controls. Working with Ford Instrument, Nordberg Manufacturing Co. will be responsible for design of the propulsion machinery.

The oil industry has shown considerable interest in this ship, since it would not require, as do conventional tankers, depletion of the oil cargo while enroute to fuel the propulsion plant. Serious interest has also been indicated by power ultility companies and mine operators in using this type of reactor for power generation.

Generally, the closed-cycle, gas-cooled concept appears to offer great promise of economical power generation in the foreseeable future because it is expected to be simple, safe and to have low installation and operating costs. The closed-cycle, gas-cooled reactor differs from other reactors in that it heats an inert gas which drives a gas turbine directly.

Pay, Plans, Placement Must All Combat Engineer Shortage

TUCSON, ARIZ.—"More than 5000 companies are being slowed down by the need for an additional 50,000 engineers," reports Industrial Psychology Inc., national psychological research organization, "Industry used one engineer for each 400 employees 75 years ago. Today, the demand is one engineer for every 40 employees. Last year industry could have used 40,000 new engineers against the 22,000 who actually got their degrees. Scientists, designers, other types of technical personnel, and even skilled workers are in the same demand."

Engineer salaries are also edging up as demand outruns supply. In 1956, engineering college graduates were being offered $400-plus a month, versus $385 in 1955. Ph.D.'s can find $10,000 to $12,000-jobs without too much trouble. The figure is $800-plus a month for 10-year men.

Salaries alone are not the full investment in technical personnel.

(*Continued on Page 22*)

DRAFTING TRENDS

"Control" is the main factor in the trend to better prints. Nothing is left to chance in Post's exclusive controlled coating process.

Blueprints and diazo prints are getting better every year

In the 1890's, uniform, sharp reproductions were hard to get . . . and for good reason! Manufacturers of sensitized papers took ordinary paper stock and the best paint brush they could buy, then *painted on* emulsions! Color of developed blueprints often varied greatly from one end of the sheet to the other.

Through the years, better blueprint and diazo papers resulted from technological advances in three fields. In the *paper industry*, mills perfected higher quality stock to accept improved emulsions. Improvements in emulsion resulted, in turn, from production of purer *chemicals*. Then, to transform superior emulsion and stock into better sensitized paper, Post designed and built their own *controlled coating* machines. Each machine rigidly controls every phase of blueprint and diazo paper production for absolute uniformity from roll to roll.

"Control" opens new era

Back in the 1890's, paper stock was not uniform . . . coating patterns varied with the skill of the brusher . . . color was pure guesswork. During the past 60 years, production of blueprint and diazo paper left the age of chance and entered an era of scientific control.

Today, sensitized emulsions and coating techniques are rigidly controlled to assure sharp line images, intense color and clear background. Base paper is carefully selected and thoroughly tested for durability, ease of trimming, and ability to take repeated creasing. Even temperature and humidity are held to close tolerances to prevent variations in print quality.

What was considered good paper and reproduction quality just a few years ago now fails to meet minimum standards. At Post laboratories new developments in paper composition, chemical production and reproduction techniques are being translated daily into still better prints.

New brochure on better prints now available

Now is the time to investigate rapid advancements in print quality. If your firm has reproduction equipment to make its own prints, write today for Post's brochure on how to get better, sharper prints through *controlled coating*.

Write to the Reader Service Division, Frederick Post Company, 3652 N. Avondale, Chicago 18, Illinois.

POST

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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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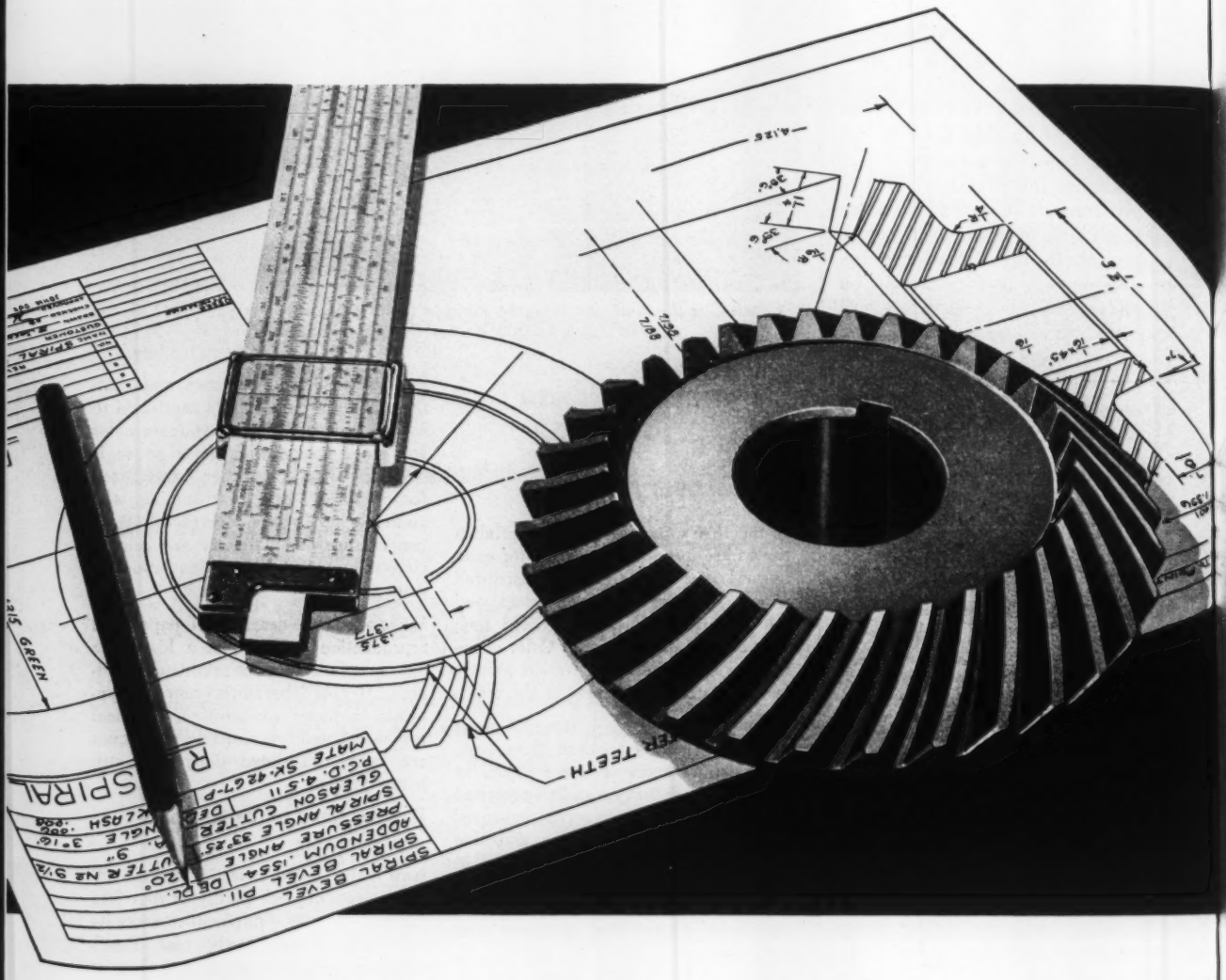
"ENGINEERED QUOTATIONS"

When our engineers study our customers' prints, they look for ways to improve gear performance, ways to simplify gear installations, ways to cut gear costs. When they find a way that they consider better they report it to the customer for his consideration. Very often these "engineered quotations" are accepted. Such careful scrutiny of every engineering and manufacturing step by *gear specialists* is one reason why so many manufacturers use Automotive Gear Works as their "gear department". May we submit an "engineered quotation" on your gear requirements?



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ESTABLISHED IN 1914 — RICHMOND, INDIANA

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Reader Information Service

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for More Information . . .

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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OCT. 18, 1956

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403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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PRODUCT MANUFACTURED _____

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Do not use this card after Dec. 18, 1956

MACHINE DESIGN
OCT. 18, 1956

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
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420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
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FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed In the United States

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MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
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9 design problems that can be met with the... Allenut

Ever-increasing applications for the new ALLENUT have caused sales to double within the past two years. Here are some of the things it can do to aid your product designing:

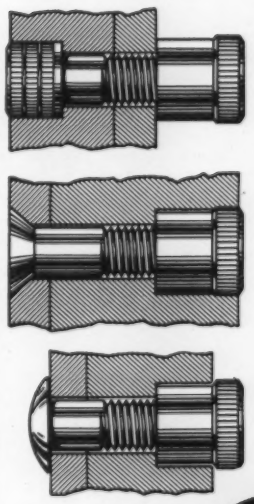
1. Self-anchoring in any metal. Allenut provides positive anchoring action through its hardened knurls.

2. Compact design. Requires no space for box wrenching. 12-point socket permits tightening in awkward places.

3. Smooth surfaces. Fits flush or below surface in counterbored hole . . . permits streamlined, safe surfaces.

4. A ready-made, hardened, tapped hole. When used as a bushing, prevents costly stripping of threads caused by frequent removal and replacement of screw or bolt. In castings and other soft metals a stripped hole can be counterbored, an Allenut inserted and the same bolt or screw used.

5. Tighter fit. Greater thread contact than with ordinary nuts because of Class 3 fit. Weld-like setups accomplished with one hand wrenching. Allenut holds firm against turn of screw.



6. Usable with any type of bolt or screw. Permits space-saving, internal wrenching of cap screws, T bolts, machine bolts, and other common fasteners.

7. Saves parts. No washers required when anchored.

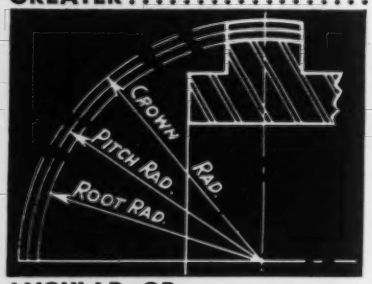
8. Easier to use. Knurled ring facilitates fingering-in. Allenut is always square to counterbored hole. Removable by hitting screw or bolt head with tap of a hammer.

9. Reusable indefinitely. Anchoring action remains unimpaired. Hardened threads and socket stand up under repeated removal and replacement.

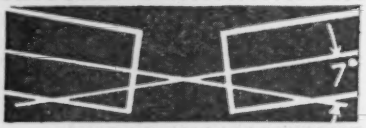
Allenuts are available in a full range of 14 standard sizes from no. 4 to 1" from leading industrial distributors.

We welcome your inquiry and request for engineering details on Allenut applications.

PERFECT SPHERICAL TOOTH FORMATION PERMITS GREATER.....



ANGULAR OR.....



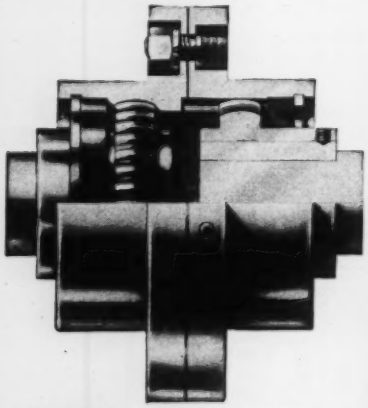
.....LINEAR MISALIGNMENT

The Philadelphia SPHEREFLEX COUPLING features a Spherical cut tooth which allows a ball and socket action between mating teeth up to 14° angular misalignment—and due to this angular capacity, a much greater amount of parallel misalignment is possible, which varies directly as the pitch diameter of the gears. All this is accomplished by gearing having a minimum back-lash.

By using Sphereflex Couplings, you can eliminate excessive bearing loads and cyclical bending stresses, which are caused by misalignment between shafts.

Send for Catalog C-560, and be convinced.

See the newest developments in Mechanical Power Transmission at our Booth #80—22nd National Power Show, New Coliseum, New York City, November 26-30.



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LIMITORQUE VALVE CONTROLS
FLUID MIXERS • FLEXIBLE COUPLINGS

Virginia Gear & Machine Corp. • Lynchburg, Va.

Circle 515 on page 19

Engineering News Roundup

(Continued from Page 15)

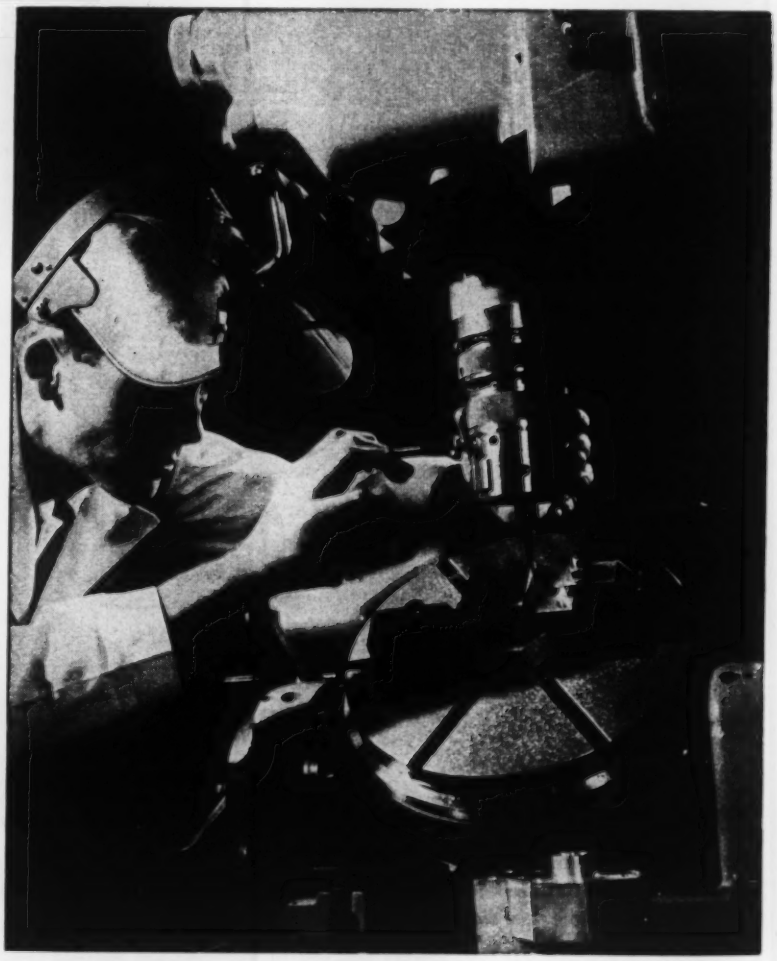
Fringe benefits run about $740 per employee per year for workers in general. Engineers receive $1000 a year on the average. The investment in an engineer with a company for six months, considering his recruiting, training, salary and fringe payment is well over $10,000.

Some areas which companies should check to combat this shortage of engineering and technical men:

Make a study of job assignments in technical departments. This might involve time studies of various engineering and technical duties, in order to eliminate waste activity and to reassign noncritical work to junior aides.

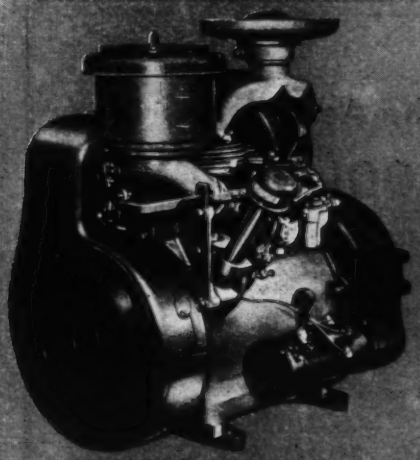
Place engineers on job assignments in terms of their psychological potential. Trained engineers can be tested to determine their usefulness in such fields as research, production, sales engineering, supervision and administration. More turnover in technical classifications is due to job misplacement than any other reason.

Other courses of action for alleviating the technical manpower shortage include: Shorten and sharpen training programs. Check planning and communications to avoid duplications and pinpoint re-



OPTICAL MEASURING SYSTEM of the Linder jig boring machine assures accurate spacing of holes to within 0.00005-in. Measurements are reflected on a screen by means of a photoelectric indicator. The machine shown is used in production of parts for small GE gas turbine engines.

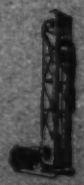
ONE ENGINE



with a knack for all trades!

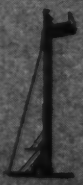
REFRIGERATION
by Tru Kooler

IRRIGATION
Pump by Warren Mfg. Co.



DRILLING
Drill Rig by
Carey Mach. and Supply, Inc.

AGRICULTURE
Windrower by
Owatonna Mfg. Corp. and
Hesston Mfg. Co.



CONSTRUCTION
Contractor's Hoist by
Buck Service Co.

MATERIALS HANDLING
by Speed-Muckin

The *FULL POWER* LYCOMING C2-90

Air-Cooled! Rated 30 h.p.—Delivers 30 h.p.!

Here's the tough, versatile engine that has an amazing variety of applications. And in this variety, the C2-90 is exposed to the most exacting working conditions . . . tested and proven in the field.

This amazing 30 h.p. unit offers you:

- The traditional air-cooled advantages of lighter weight, lower cost, all-weather performance, and superior endurance.
- FULL POWER performance—rated at 30 h.p.—*delivers* 30 h.p.!
- Highest horsepower and torque per cu. in. displacement in air-cooled field.
- Complete interchangeability—identical mounting and shaft dimensions with other major air-cooled industrial engine units in horsepower range.
- Reliability and simplicity for easy maintenance.

Yes! This engine does just what we say it will do. That's why it has been chosen by leading equipment manufacturers like those in the applications illustrated. Find out how Lycoming's 45 years of engine-building experience can solve your problems. Write:

Sales Engineering, Industrial Engines, Lycoming, Williamsport, Pa.

avco Lycoming

defense and industrial products

Circle 414 on page 19

NOW ...The Aerosol Lubricator

MACHINE TOOL DESIGNERS

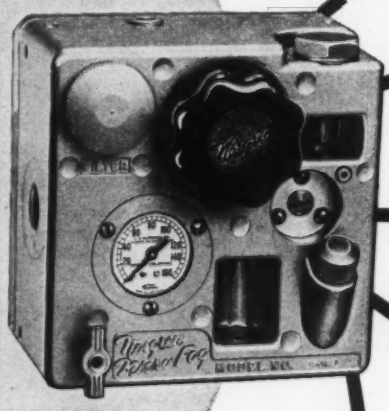
Have been asking for

Norgren

MICRO-FOG® 33AG-4

COMPACT
This new unit measures 6-1/32" x 5-3/16" x 6-1/32".

COMPLETE
Includes an Air Line Filter, a relieving type Air Pressure Regulator, and a MICRO-FOG Lubricator with a large, ⅝ pint oil capacity.



ATTRACTIVE
Blends in with smooth flowing design lines . . adds to the appearance of a machine tool.

Model 33AG-4
Lubro-Control Unit

- Filter
- Regulator
- Lubricator

EASY TO INSTALL
Offers in-line pipe connections—optional locations of air inlet and filter drain. Has two outlets for filtered air —one for MICRO-FOG.

EASY TO MAINTAIN
No tools needed to reach filter element or to refill oil reservoir. Back cover is removable.

For complete information about the new 33AG-4 unit, call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY FOR BROCHURE 556.

MICRO-FOG® by C. A. Norgren CO.

3442 SO. ELATI ST., ENGLEWOOD, COLORADO

News Roundup

sponsibility. Keep up with the literature published by such groups as the Engineering Manpower Commission on efficient utilization of engineering manpower. Employ engineering students for part-time work. Use retired engineers as consultants.

The Society of Automotive Engineers has moved into new offices at 485 Lexington Ave., New York 17, N. Y.

Meetings

AND EXPOSITIONS

Oct. 30-Nov. 1—

National Fluid Power Association. Fall Meeting to be held at the Hotel Cleveland, Cleveland. Further information can be obtained from association headquarters, 1618 Orrington Ave., Evanston, Ill.

Oct. 31-Nov. 2—

Gray Iron Founders Society Inc. Annual Meeting to be held at The Homestead, Hot Springs, Va. Additional information is available from society headquarters, 930 National City — E. Sixth Bldg., Cleveland 14, O.

Oct. 31-Nov. 2—

Society for Experimental Stress Analysis. Annual Meeting and Exhibit to be held at the Deshler-Hilton Hotel, Columbus, O. Further information can be obtained from society headquarters, P. O. Box 168, Cambridge 39, Mass.

Nov. 1-2—

Society of Automotive Engineers. National Diesel Engine Meeting to be held at the Drake Hotel, Chicago. Further information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Nov. 2-3—

Sixth Annual Tool Engineering Conference to be held at Illinois Institute of Technology, Chicago. Conference is sponsored by IIT,

Northwestern and Illinois universities and the Illinois chapters of the American Society of Tool Engineers. Further information can be obtained from Prof. Samuel E. Rusinoff, Mechanical Engineering Dept., Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Nov. 7-9—

Steel Founders' Society of America. Technical and Operating Conference to be held at the Carter Hotel, Cleveland. Additional information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, O.

Nov. 8-9—

Society of Automotive Engineers. National Fuels and Lubricants Meeting to be held at the Mayo Hotel, Tulsa, Okla. More information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Nov. 12-16—

National Electrical Manufacturers Association. Annual Meeting to be held at the Traymore Hotel, Atlantic City, N. J. Further information is available from association headquarters, 155 E. 44th St., New York 17, N. Y.

Nov. 13-15—

Investment Casting Institute. Fourth Annual Meeting to be held at the Sheraton Cadillac Hotel, Detroit. In addition, a Vacuum Metals Symposium will be held Friday, November 16. Further information can be obtained from ICI headquarters, 27 E. Monroe, Chicago 3, Ill.

Nov. 14-17—

Society of Naval Architects and Marine Engineers. Sixty-fourth Annual Meeting to be held at the Waldorf-Astoria Hotel, New York. Further information can be obtained from society headquarters, 74 Trinity Place, New York 6, N. Y.

Nov. 15-16—

Operations Research Society of America. Tenth National Meeting to be held at the Hotel Mark Hopkins, San Francisco. Additional

NEW ... All the Advantages of Norgren MICRO-FOG®
in a compact, cabinet Lubro-Control Unit

... FOR AIR OPERATED MACHINE TOOL COMPONENTS
- FEED MECHANISMS
- CHUCKS
- CLUTCHES
- BRAKES

FILTER REMOVES SOLIDS, LIQUIDS, from compressed air. Choice of 64 or 25 micron filter element. Optional location of drain.

EXACT CONTROL OF AIR PRESSURE by relieving type air pressure regulator. 150 psi. max. primary pressure —adjustable range 0-125 psi

EFFICIENT, MICRO-FOG LUBRICATION Creates finely-divided oil fog that can be uniformly distributed to multiple lubrication points. Operating range at 80 psi. is 4 to 85 cfm.

VISIBLE OIL FEED makes possible adjustment of proper rate of oil flow. Positive proof of operation. Rate of feed accurately controlled by auxiliary air circuit.

Model 33AG-4 Lubro-Control Unit
- Filter
- Regulator
- Lubricator

EASY-TO-SEE OIL LEVEL shows at a glance when oil replenishing is necessary. Easy to fill large ½ pint oil reservoir

QUICK MAINTENANCE No tools needed to reach filter element or to refill oil reservoir. Back cover is removable.

For complete information about the new 33AG-4 unit, call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY FOR BROCHURE 558.

MICRO-FOG® by C. A. Norgren CO.
3442 SO. ELATI STREET, ENGLEWOOD, COLORADO

Circle 518 on page 19

Westinghouse pilot plant for precision castings speeds development, saves capital investment

Proving ground for castings

Now . . . without heavy capital investment . . . you can prove your ideas and developmental work for molded metal products.

Modern pilot plant facilities are available at the new Westinghouse metals plant, Blairsville, Pa., to help you explore full production conditions and create prototype quantities. Here you can compare conveniently all types of castings at one place from the same heat.

Open production capacity is also available for fast, dependable delivery on precision investment castings (lost wax process), shell-mold castings and powder metal parts.

In making a value analysis of your product components, consider molded metal parts for pieces involving intricate shapes, close tolerances, difficult machining operations or component assemblies. You save machining, improve finishes, reduce rejections.

Send today for further details and a copy of DB 52-500. Also enclose a photo, drawing or sample of the part you want evaluated. No obligation. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-05001

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING **TODAY!***

News Roundup

information can be obtained from Operations Research Office, Johns Hopkins University, 7100 Connecticut Ave., Chevy Chase 15, Md.

Nov. 25-30—

American Society of Mechanical Engineers. Annual Meeting to be held at Hotel Statler, New York. Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

Nov. 25-30—

22nd National Exposition of Power and Mechanical Engineering to be held at the Coliseum, New York, under the auspices of the American Society of Mechanical Engineers. Additional information can be obtained from exposition headquarters, 480 Lexington Ave., New York 17, N. Y.

Dec. 9-12—

American Institute of Chemical Engineers. Annual Meeting to be held at Hotel Statler, Boston. Further information can be obtained from the institute's headquarters, 120 E. 41st St., New York 17, N. Y.

Dec. 9-12—

American Society of Agricultural Engineers winter meeting to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from society headquarters, 420 Main St., St. Joseph, Mich.

Dec. 10-11—

Material Handling Institute Inc. Annual Meeting to be held at the Biltmore Hotel, New York. Further information can be obtained from institute headquarters, Suite 759, 1 Gateway Center, Pittsburgh 22, Pa.

Dec. 10-12—

1956 Eastern Joint Computer Conference to be held at the Hotel New Yorker. Sponsors are the Institute of Radio Engineers, American Institute of Electrical Engineers and the Association for Computing Machinery. Additional information is available from publicity chairman Albert J. Forman, Tele-Tech & Electronic Industries, 480 Lexington Ave., New York 17, N. Y.

MEN

OF MACHINES

Kellett Aircraft Corp., Camden, N. J., has announced the appointment of **Leonard Goland** as director of research. Mr. Goland previously served as a chief project engineer at Forrestal Research

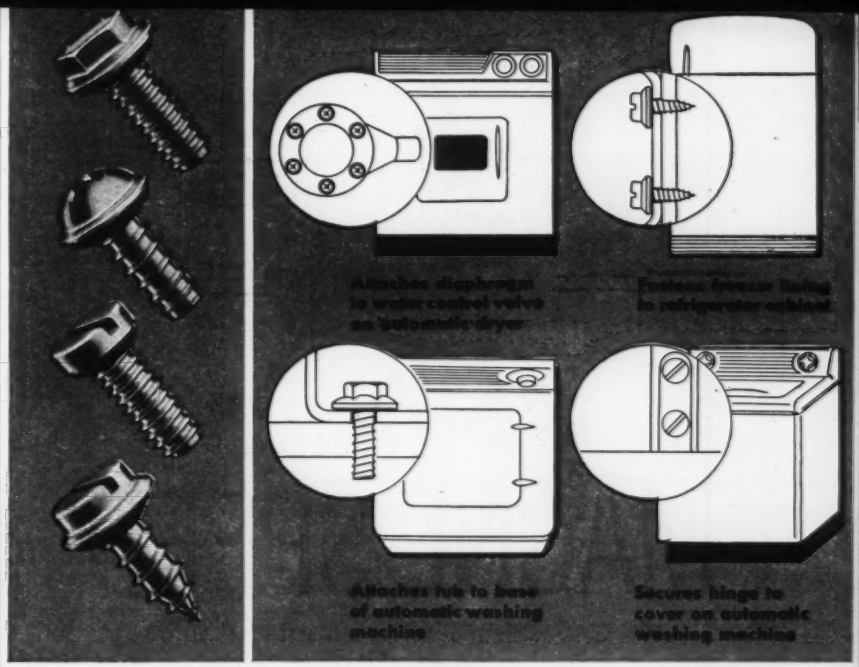
Leonard Goland

Center and instructor in the graduate school of Princeton University; and head of the engineering analysis section of Reaction Motors.

Kellett has also appointed **Al Yackle** chief of special projects, **Blair Baisley** chief of structures and **David Gebhard** chief of preliminary design.

Donald J. Gimpel has joined the Research and Development Dept. of Panellit Inc., Skokie, Ill. Dr. Gimpel will have charge of the company's electronic projects and will aid in development of the systems research program.

Dana H. Bailey has been named director of new products and process development by Harris Calorific Co., Cleveland. Mr. Bailey has served as an associate professor at Pennsylvania State College, an experimental engineer at the Pfaudler Co., chief design engi-


Attaches diaphragm to water control valve on automatic dryer
Fastens freezer lining to refrigerator cabinet
Attaches tub to base of automatic washing machine
Secures hinge to cover on automatic washing machine

Townsend *Tuff-Tites*®

Offer Appliance Manufacturers Lower Costs and Superior Performance

Leading appliance manufacturers are cutting production costs and improving their products by adopting Townsend Tuff-Tite fasteners. The one-piece head and washer construction of Tuff-Tites eliminates a major source of leakage. The additional pre-assembled neoprene washer not only serves to eliminate leakage, but also protects porcelain enamel surfaces from scratches and mars. Since they are resistant to vibration, Tuff-Tites have any number of applications in the appliance field.

If you have a fastening problem, Townsend specialists will be glad to make recommendations as to the proper Tuff-Tite to meet your needs. If a standard item cannot be used, Townsend engineers will design a custom-made fastener to answer your purpose.

For complete information, write to Townsend Company or use the coupon below.

The Fastening Authority

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COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Chevy River Division • Santa Ana, California

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Please send to me without obligation "Tuff-Tite" Bulletin TL-97.

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Company_____

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City_____ Zone_____ State_____

Circle 520 on page 19

Magnetic Amplifiers · INC

VARIABLE SPEED DRIVE

MAGNE-SPEED*

*Trade Name

Stepless, instant starting, compact, 50:1 speed range, good regulation without tachometer, long life, virtually maintenance free service, low cost, fast response, reversibility, dynamic brake, local or remote control. Write for Bulletin S580-5-55.

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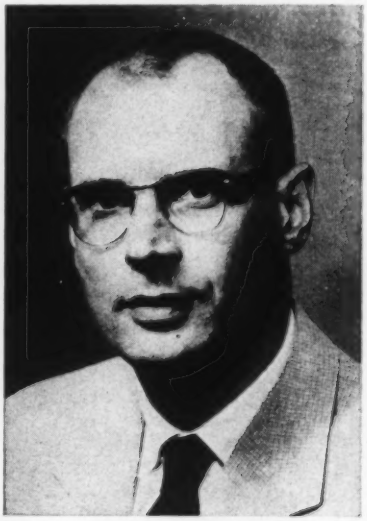
632 TINTON AVE., NEW YORK 55, N. Y.—CYpress 2-6610
West Coast Division
136 WASHINGTON ST., EL SEGUNDO, CALIF. — EAstgate 2-2056

Men of Machines

neer for the John R. R. Miles Welding Equipment Co. and chief engineer at Sta-Rite Products Co. He came to Harris Calorific as a project engineer in 1945.

Lux Clock Mfg. Co., Waterbury, Conn., has appointed **Dwight E. Harris** chief engineer and head of its recently expanded development



Dwight E. Harris

and product application departments. Mr. Harris was formerly chief engineer of Winchester Electronics, Inc.

Recent appointments at Lockheed Aircraft Corp., Burbank, Calif., include the election of **Hall L. Hibbard** as vice president of engineering and a member of the new Corporate Policy Committee and the appointment of **Clarence L. Johnson**, former vice president of research and development, to vice president of engineering and research.

Gerhard Reethof has been named chief of research and **LeRoy D. Taylor**, assistant chief engineer for development by Vickers Inc., Detroit. Dr. Reethof was an assistant professor of mechanical engineering at Massachusetts Institute of Technology with research duties at the Dynamic Analysis and Control Laboratory. He has also been associated with Sperry Gyroscope and General Electric Co. Mr. Taylor joined Vickers in

1948 as a member of an engineering group investigating hydraulic servo systems and related equipment and devices. In 1954 he was made director of projects leading to the development of special hydraulic valves and actuators for aircraft surface controls.

The Martin Co., Baltimore, has promoted **Samuel Storchheim** to chief of manufacturing engineering and research in its Nuclear Div. Prior to joining Martin in 1955 Mr. Storchheim was associated with the Radio Corp. of America, the William B. Driver Co. and the Atomic Energy Div. of Sylvania Electric Products Corp.

Andrew B. Huntington has been named chief engineer of Ross Operating Valve Co., Detroit. Mr. Huntington has been associated

Andrew B. Huntington

with Ross since 1952 as manager of production engineering. He was formerly a project engineer for the U. S. Rubber Co. and was also affiliated with Lalance & Grosejean Mfg. Co.

Acme Steel Co., Chicago, has named **Hugh D. Connell** manager of the Project Engineering Dept. Mr. Connell joined the company in 1947.

As a result of recent changes in its organizational structure, the Lamson Corp., Syracuse, N. Y.,

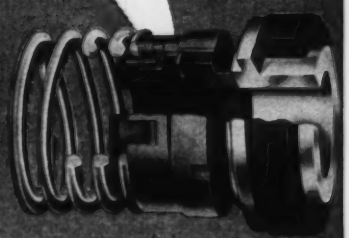
YOU insure
RUGGED FIELD PERFORMANCE
plus PRODUCTION SAVINGS

when you specify these
JOHN CRANE MECHANICAL SEALS

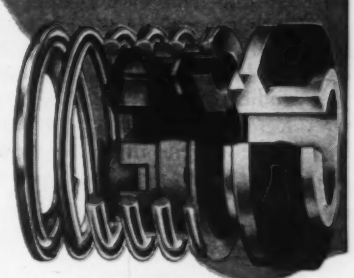
"JOHN CRANE" Types 1 and 2 shaft seals come pre-assembled. They are quickly and easily installed. Tolerances need not be critical due to the self-adjusting seal head. This is accomplished through special construction of the synthetic rubber bellows head. Moving freely under spring and hydraulic pressure, it automatically compensates for shaft end play, as well as washer wear.

Sealing faces are precision-lapped to prevent stuffing box leakage. No break-in runs necessary. Positive drive feature eliminates all stress on bellows. This feature also permits the use of light spring load to minimize wear on sealing faces. Seal needs no attention over long periods of operation.

Recommended for water, oil and other services non-injurious to synthetic rubber. Pressures to 200 psi. Temperatures: –40° to +212°F.



Type 1. For stuffing boxes of limited diameter.



Type 2. For stuffing boxes of limited length.

Above seals also available in balanced construction (1-B, 2-B) for pressures up to 500 psi.

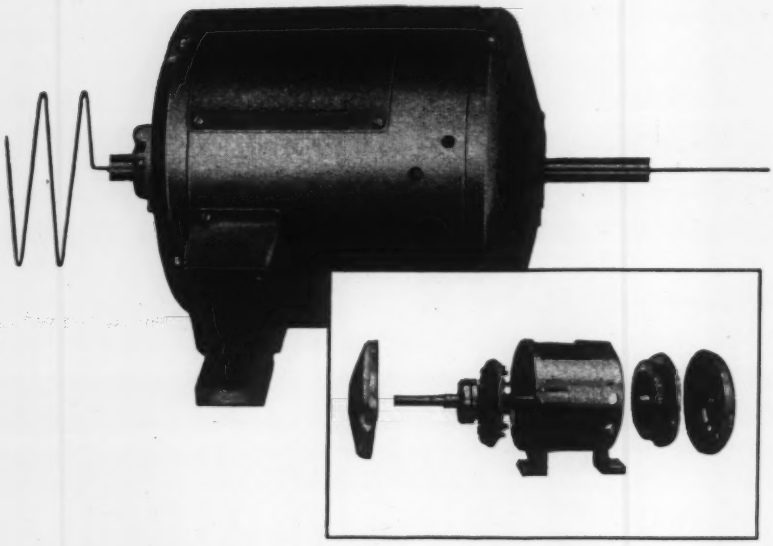
Write for Bulletin S-213-1

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill., (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton Ont.

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS

Circle 522 on page 19

SPECIAL



rotary rectifier for speed control

This is a unique, commutating device, specially built by ESCO, to provide a signal used for accurate, wide-range speed control for a variable frequency alternator.

It's a rectifier because it supplies a DC speed control current from an AC alternator output. Special windings in the alternator impress a "revolving voltage" on a fixed commutator within the device. Rotating brushes collect this voltage, in proper synchronization, to deliver a DC output through two slip rings. This output is exactly proportional to the air gap flux of the alternator and is used to control the drive motor speed. This particular method was chosen for its exceptionally smooth, accurate control over a wide speed range from well below 100 rpm to above 4,000.

This is typical of ESCO's unusual ability to design special rotary equipment to meet customer needs. Whether or not your problem is this special, remember ESCO's forty years of broad experience is always available to you. No motor or generator problem is too big or small, too routine or specialized for ESCO engineers and craftsmen.

Refer to Esco Catalog in section 4a/EL in Sweet's Product Design File, or write direct for general catalog No. 56PD. Why not also send us details on your special problem . . . we'll be glad to show you how we would go about solving it for you.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

Men of Machines

has announced the election of **Harry C. Keller** as a vice president. He will be in charge of the broad phases of new product research and certain special developments and will also act as a consultant on all engineering and development problems.

Richard E. Tisch has been named manager of the new product development engineering department of Minnesota Rubber & Gasket Co., Minneapolis. The new department will conduct research development and testing operations on all new products originated by the firm. Mr. Tisch was formerly associated with the Pacific Div. of Bendix Aviation Corp. as senior test engineer and supervisor of the hydraulic and electromechanical engineering test laboratory.

American Motors Corp. has announced the promotion of **John Adamson** to staff assistant. Mr. Adamson joined Nash Motors in 1947 and has been assistant to the chief design engineer of the Nash research department since 1952.

Richard R. Kesti was recently appointed chief engineer of Valvair Corp. and Sinclair-Collins Valve Co., Akron, O. Mr. Kesti will head the general engineering divisions of both firms. He was group engineer in charge of missile valve and control component

Richard R. Kesti

design and development for Chrysler Corp. and previously served as a design engineer in the missile valve and control component section of Redstone Arsenal.

Pio Franco Martinuzzi has been appointed technical consultant to the vice president of engineering at Ford Instrument Co. Div. of Sperry Rand Corp. Dr. Martinuzzi has worked as automobile and aircraft engine designer and consultant in Italy, France and Great Britain. During World War II he became a specialist in the field of gas turbines.

Westinghouse Electric Corp., Pittsburgh, has named **M. A. Nelson** engineering manager of its steam division. Mr. Nelson has been associated with Westinghouse since 1929 and has served as section manager of heat transfer apparatus since 1940.

The appointment of **James B. Wilkie** as manager of the gage division has been announced by Pratt & Whitney Co. Inc., West Hartford, Conn. Mr. Wilkie has been associated with the company since 1935.

Eli M. Goldfarb has been named senior project engineer by Levinthal Electronic Products Inc., Redwood City, Calif. Mr. Goldfarb previous'y served as a research associate in the electronics research laboratory at Stanford University, a research engineer in the jet propulsion laboratory at the California Institute of Technology, and a mechanical design engineer at Piper Engineering Co.

Jet-Heet Inc., Englewood, N. J. recently named **Aldo Macchi** a project engineer in charge of all special projects dealing with heating equipment. Mr. Macchi was formerly a design engineer in the air conditioning division of General Electric Co.

Ohio Seamless Tube Div. of Copperweld Steel Co., Shelby, O., has named **Francis S. Coleman** chief engineer. He has been assistant chief engineer and is succeeded in that position by **George P. Jones.**

with
BIJUR
AUTOMATIC
LUBRICATION

Bijur Automatic Lubricating Systems designed into your machines *from the start* help you build an early lead in customer satisfaction.

And with Bijur you are *right* because for a quarter of a century Bijur Automatic Lubricating Systems have been part of efficient production programs.

Your customers prefer automatic lubrication in the equipment they buy because it increases production and reduces operating costs. Built into your original plans for machinery production, a Bijur Automatic Lubricating System can work for you by increasing customer acceptance, assuring bearing safety, and contributing to operating efficiency.

Call in a Bijur lubrication engineer. He is ready to help with your technical problems.

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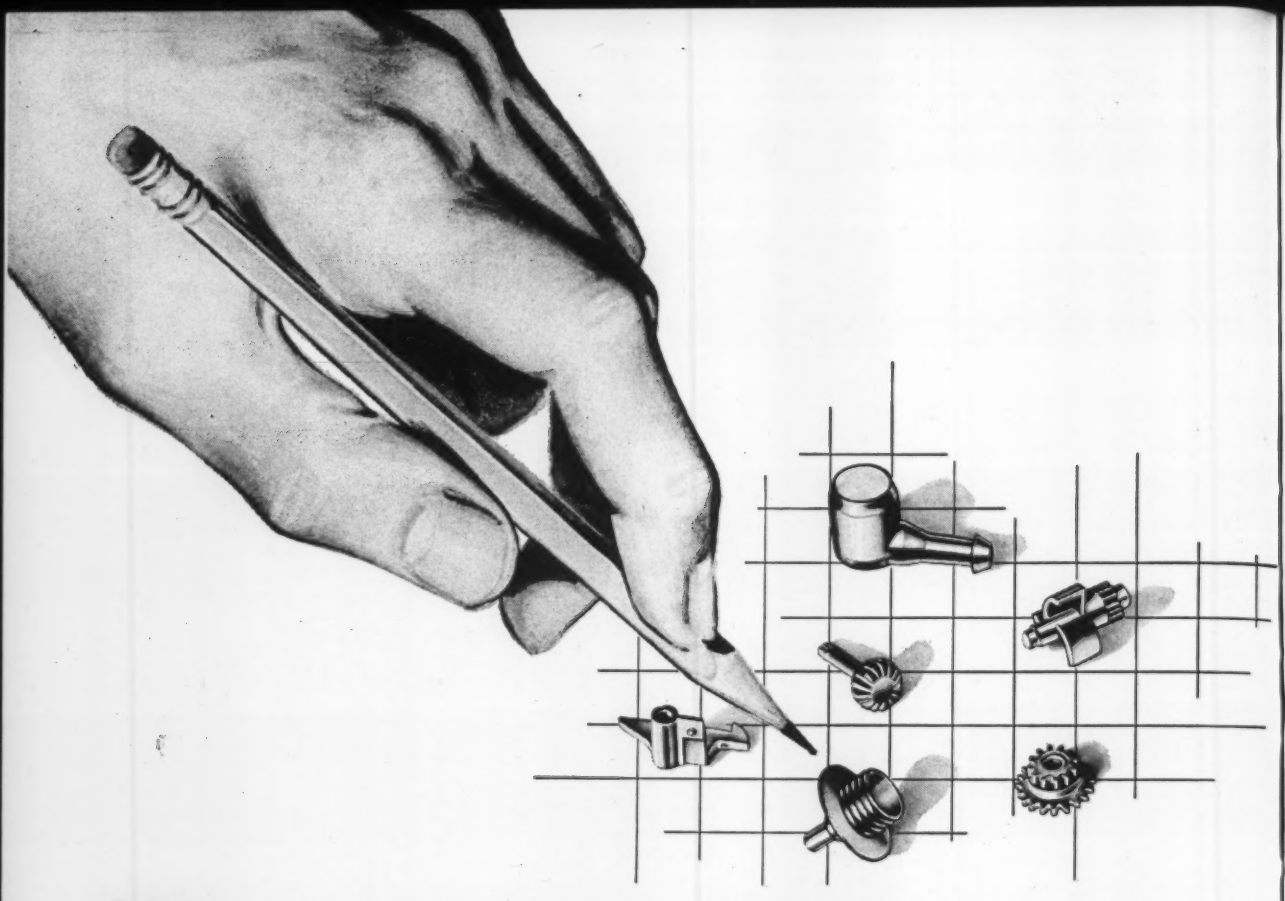
BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey

Pioneers in Automatic Lubrication



GRC's small parts are doing a **big job** for industry:

helping product planners improve design while substantially reducing costs.

Yes, almost any industry you can name is benefitting from Gries' unusual small parts' manuracturing techniques. Exclusive GRC patented techniques and specialized machinery are giving design engineers wider latitude in their plans, enabling them to solve hitherto "impossible" parts problems, and to take advantage of many time- and money-saving short cuts. Broadly, GRC offers facilities for custom diecasting and plastic-molding of tiny parts; whichever the method, each part is engineered and manufactured to do its job better, because it is made better—at less cost.

GRC SPECIALIZED DIECASTING

Mass-produced in quantities from 100,000 to many millions, GRC's corrosion resistant zinc-alloy small parts are diecast in one automatic operation, completely trimmed and ready for use. Smallness and intricacy are unlimited—maximum length 1¾", weight up to ½ oz. Cost you less, because welding, scrap loss, expensive tools, machining, and assembly are eliminated or reduced—design is simplified. GRC has complete facilities for low-cost secondary machining and finishing.

GRC'S EXCLUSIVE INTERCAST PROCESS gives you completely *cast-assembled* small parts in single units or continuously interlocked assemblies. Maximum unit length 1½", maximum weight ½ oz.

GRC INJECTION PLASTIC MOLDING

Parts up to .03 oz. in weight and 1¼" long are economically molded of nylon or any other thermoplastic. Gries' unique molding technique minimizes shrinkage problems of nylon and makes the most of its important mechanical and electrical properties.

AUTOMATIC INSERT MOLDING. Gries has exclusive facilities for molding individual inserts and molding plastic elements on continuous inserts, such as wire, cord, etc.

GRC INDUSTRIAL FASTENERS

A complete line of zinc-alloy diecast wing nuts, cap nuts, thumb-nuts, wing screws, rivets; stocked for immediate delivery in any quantity. Rustproof, accurate, and durable, in plain bright and all commercial finishes.

GRC STANDARD PARTS

A large variety of zinc-alloy diecast standard and specialized components for open-stock orders. Includes such items as gears, pinions, rings, buckles, and thousands of components for all industry —all of the same quality and finishes as GRC fasteners.

WRITE, WIRE OR PHONE TODAY

for copies of BULLETINS describi GRC SERVICES and PRODUCTS:

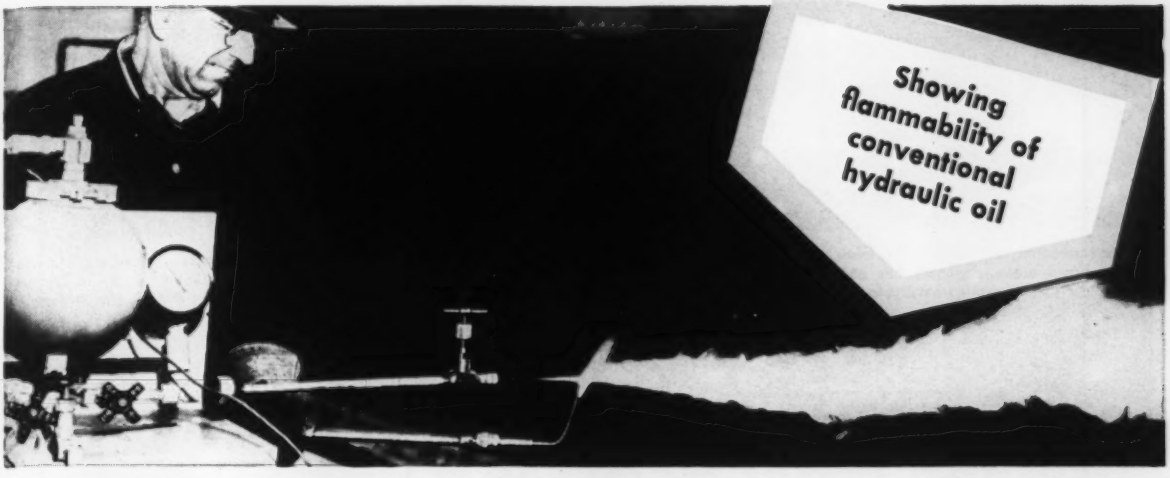
- ☐ Small Parts Diecasting
- ☐ Small Parts Plastic Molding
- ☐ Industrial Fasteners
- ☐ Stock Sheet — Gear & Pinions
- ☐ Standard Products

GRIES

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Diecastings • 32 Second St., New Rochelle, N. Y. • NEw Rochelle 3-860

Circle 525 on page 19



Flame tests prove its fire-snuffing ability

SHELL IRUS FLUID 902

Entirely new formula: Shell Irus Fluid 902 is a special formulation . . . product of three years' development and field testing. It is suitable for nearly all industrial hydraulic systems, as a direct replacement for presently used oils. *Here is a fire-resistant hydraulic fluid that can be widely used.*

Non-corrosive: Shell Irus Fluid 902 contains no corrosive ingredients. It has no harmful effects on seals, fittings or bearings. It does not promote rust.

No major modification necessary . . . simply clean present fluid thoroughly out of system and replace directly with Shell Irus Fluid 902. You can use it with complete confidence. Write for test data and all information.

SHELL OIL COMPANY

50 WEST 50TH STREET, NEW YORK 20, NEW YORK
100 BUSH STREET, SAN FRANCISCO 6, CALIFORNIA

SHELL

Circle 526 on page 19

Square corrugated trailer siding fabricated on brake press. Reynolds has available brake presses ranging from 22½ to 300 tons.

Washing machine tubs fabricated here are one example of countless quality parts fabricated by Reynolds.

1700-ton hydraulic press in a Reynolds plant used on 12' x 4'8" aluminum boat hull. Press is currently used on drawn parts 6' in dia.

from tumblers to trailers... get the most from your designs with

ALUMINUM

PRESS PARTS

fabricated and finished by REYNOLDS

If your designs call for aluminum parts that require blanking, punching, drawing, forming, stamping, piercing or other press operations, Reynolds can fabricate these parts—and finish them—to your specifications quickly, efficiently and economically.

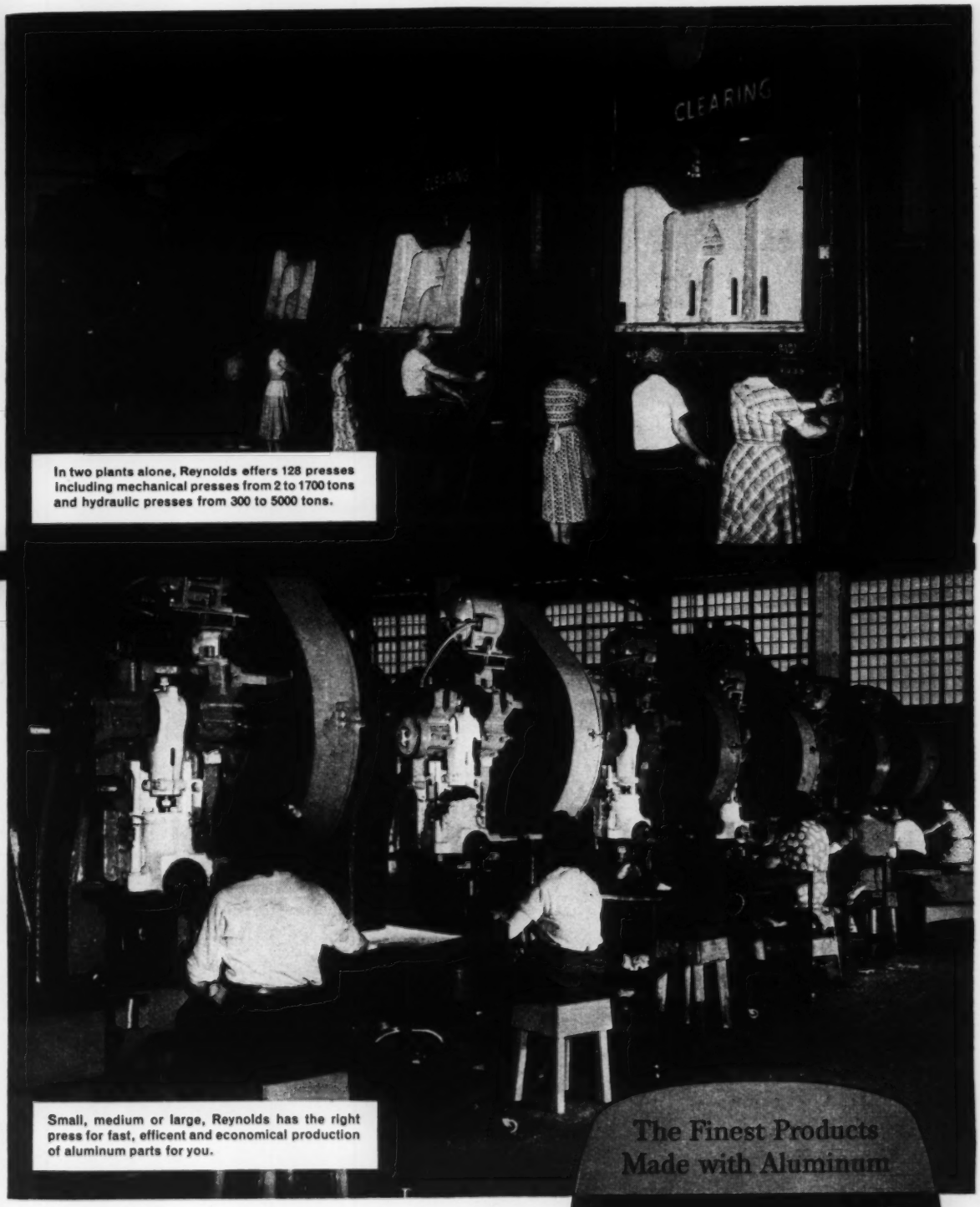
The great variety of Reynolds specialized equipment gives you the economy of the machines best suited to your purpose without making the tremendous capital investment in equipment and added plant capacity which would otherwise be required. Reynolds can furnish press parts from simple blanks to deep drawn parts of large area; from very thin to the thickest aluminum that can be drawn.

And—when an unusually high quality finish is important to the sales appeal of your aluminum product—Reynolds expanded finishing facilities are your best source for clear anodized, color anodized, chemically brightened or other fine finishes. Reynolds quality control from mine to finished product and Reynolds experienced design and engineering service go hand in hand with these facilities to assure you the most from your designs.

For full details on press parts and other services, call the Reynolds Office listed under "Aluminum" in your classified telephone directory or write *Reynolds Aluminum Fabricating Service, 2061 South Ninth St., Louisville 1, Ky.*

Watch for Reynolds new program, "Circus Boy"—Sundays on NBC—TV

REYNOLDS ALUMINUM FABRICATING SERVICE



In two plants alone, Reynolds offers 128 presses including mechanical presses from 2 to 1700 tons and hydraulic presses from 300 to 5000 tons.

Small, medium or large, Reynolds has the right press for fast, efficent and economical production of aluminum parts for you.

The Finest Products Made with Aluminum are made with

REYNOLDS ALUMINUM

BLANKING • EMBOSSING • STAMPING • DRAWING • RIVETING

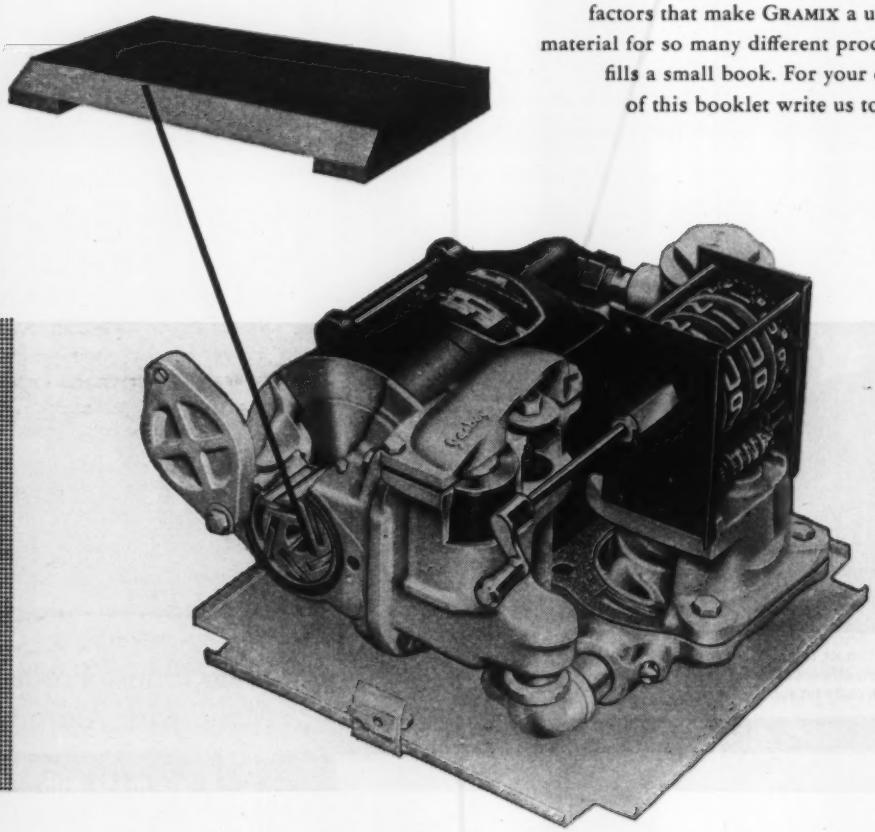
FORMING • ROLL SHAPING • TUBE BENDING • WELDING • BRAZING • FINISHING

Circle 527 on page 19

GRAMIX® vanes in Gasboy® pump wear only .031" per ONE MILLION GALLONS

The Gasboy Super "200" gasoline pump is manufactured exclusively for farms, fleets, and industry by Wm. M. Wilson's Sons, Inc. in Lansdale, Pa. These pumps have proven to be accurate, efficient and dependable. But, what naturally interests us and will interest you, as a manufacturer or designer, are the GRAMIX vanes in these pumps. Tests reveal that the GRAMIX Grade 41 vanes still operated perfectly after pumping over 1,000,000 gallons of gasoline. During this endurance test, the vanes travelled around the inside of the housing a distance equal to 13,000 miles, or more than half way around the earth!

Not only these particular vanes, but hundreds of other GRAMIX parts are doing a successful job in appliances, aircraft, automobiles and an amazing variety of products. GRAMIX parts are die-pressed to close tolerances, and need no machining. They are strong, they are self-lubricating. The many factors that make GRAMIX a useful material for so many different products fills a small book. For your copy of this booklet write us today.



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THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Circle 528 on page 19

Circle 530 on page 19→

NOSCO "CAN DO"

TWO different refrigerator trays from ONE CONVERTIBLE MOLD

One of America's largest refrigerator manufacturers needed two trays with the same over-all dimensions and needed them fast! Their deluxe tray required a pocket to contain an insulation pad; their standard model required no insulation.

Here's where NOSCO "Can Do" came into play. Our engineers devised one *convertible mold,* which, with the addition of inserts, would produce either tray.

Nosco designed this mold so that insert parting lines were attractively blended into the tray design. By efficient high-production molding—a fundamental of NOSCO "Can Do"—we met the delivery requirement, and our customer was saved the cost and time of an expensive extra mold!

Nosco molded the two trays, also spray-decorated and conveyor-assembled them to the customer's complete satisfaction. Just one more happy example of NOSCO "Can Do." Why not let us send the Nosco Sales Engineer near your plant to start NOSCO "Can Do" working on your next plastic part.

NOSCO plastics, inc. • erie 2, pa.

World's largest injection molding plant

For other case histories—and a glimpse of the Nosco plant and facilities, send for the free 12-page brochure.

Nosco Plastics, Inc., Erie 2, Pa. Send____copies of brochure: "How the Nosco Plant Works to Produce Your Needs in Practical Plastics."

NAME_____ TITLE_____

FIRM_____

ADDRESS_____

CITY_____ STATE_____

Circle 530 on page 19→

G-E general purpose control

Hydra-clutch Headstock with G-E controls automatically changes pre-selected spindle speeds for each hexagon turret position.

G-E PANEL PROVIDES AUTOMATIC SPEED SELECTION FOR EACH OF 6 TURRET FACES

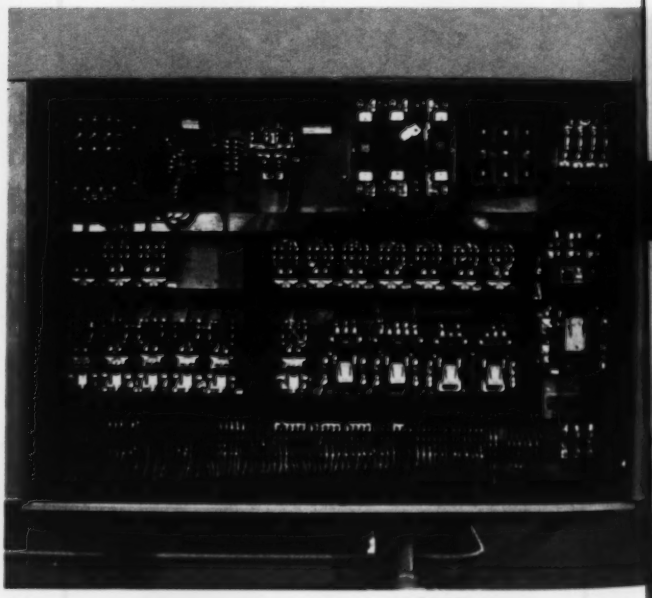
The new Hydra-clutch Headstock manufactured by the Jones & Lamson Machine Company is controlled by a General Electric factory-built Pan-A-trol packaged control panel. This machine is designed to reduce machine handling time and operator fatigue.

Equipped with a power indexed hexagon turret, the Headstock features pre-selected spindle speeds which are automatically changed for each of the six turret faces. Speed selection and changes, and power indexing are controlled by G-E oil-tight push buttons and selector switches, along with indicating lights, in the operator's station.

The factory-built panel is constructed to JIC standards, and contains standard high-quality G-E starters, machine tool relays, pneumatic time-delay relay, and other devices. The machine tool relays control the power feed and indexing of the turret head.

Latched-in forms of the machine tool relay control solenoid valves. Spindle speed changes are accomplished by these valves engaging or disengaging hydraulically operated multiple-disc clutches.

This Pan-A-trol packaged control panel was shipped from our factory completely wired. Only connections from the machine to the panel terminal board had to be made.



PAN-A-TROL PANEL was factory-built to JIC standards. Panel provides: motor starting; motor reversing; motor overload protection; over-current protection; and a disconnecting means.

GENERAL ELECTRIC'S NEW

Machine Tool and Time-Delay Relays Control New 32-speed Headstock

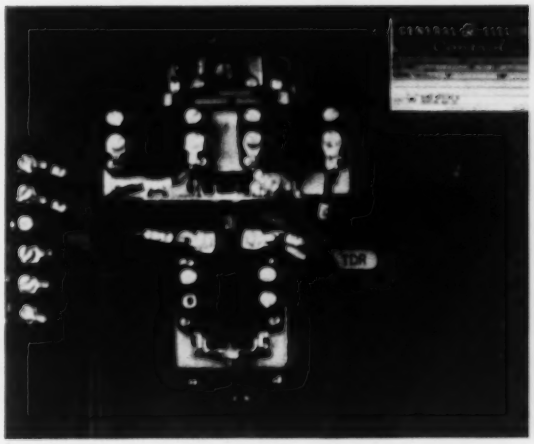
General Electric's new machine tool relays and pneumatic time-delay relay, installed in a G-E factory-built Pan-A-trol* packaged control panel, provide precise control for this 32-speed Hydra-clutch Headstock, manufactured by Jones & Lamson Machine Company of Springfield, Vermont.

MACHINE TOOL RELAYS offer a high degree of dependability on automatic machinery such as this Headstock. The Strongbox coil in the machine tool relay is molded in a polyester resin to seal out moisture and oil. Permanently attached contact springs assure proper tip pressure. Also, contacts change from normally open to normally closed without extra parts.

PNEUMATIC TIME-DELAY RELAY provides high repetitive accuracy with negligible effect from humidity or atmospheric pressure changes. It is adjustable from 0.2 to 180 seconds. A rigid die-cast aluminum base prevents misalignment which might affect relay accuracy.

FOR MORE INFORMATION, contact your nearest General Electric Apparatus Sales Office, or write Advertising and Sales Promotion, Section 731-4, General Electric Company, Bloomington, Illinois.

* Trade-mark of General Electric Co.

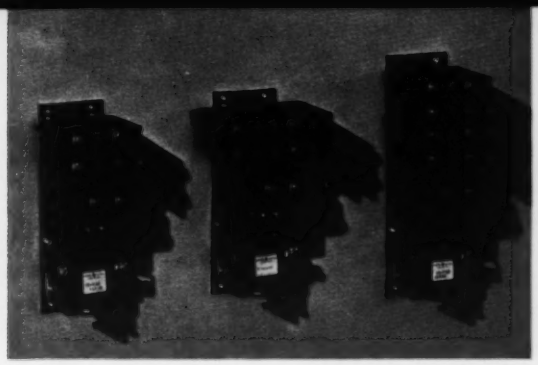


PNEUMATIC TIME-DELAY RELAY prevents operation of power wrench on Headstock before it stops spinning.

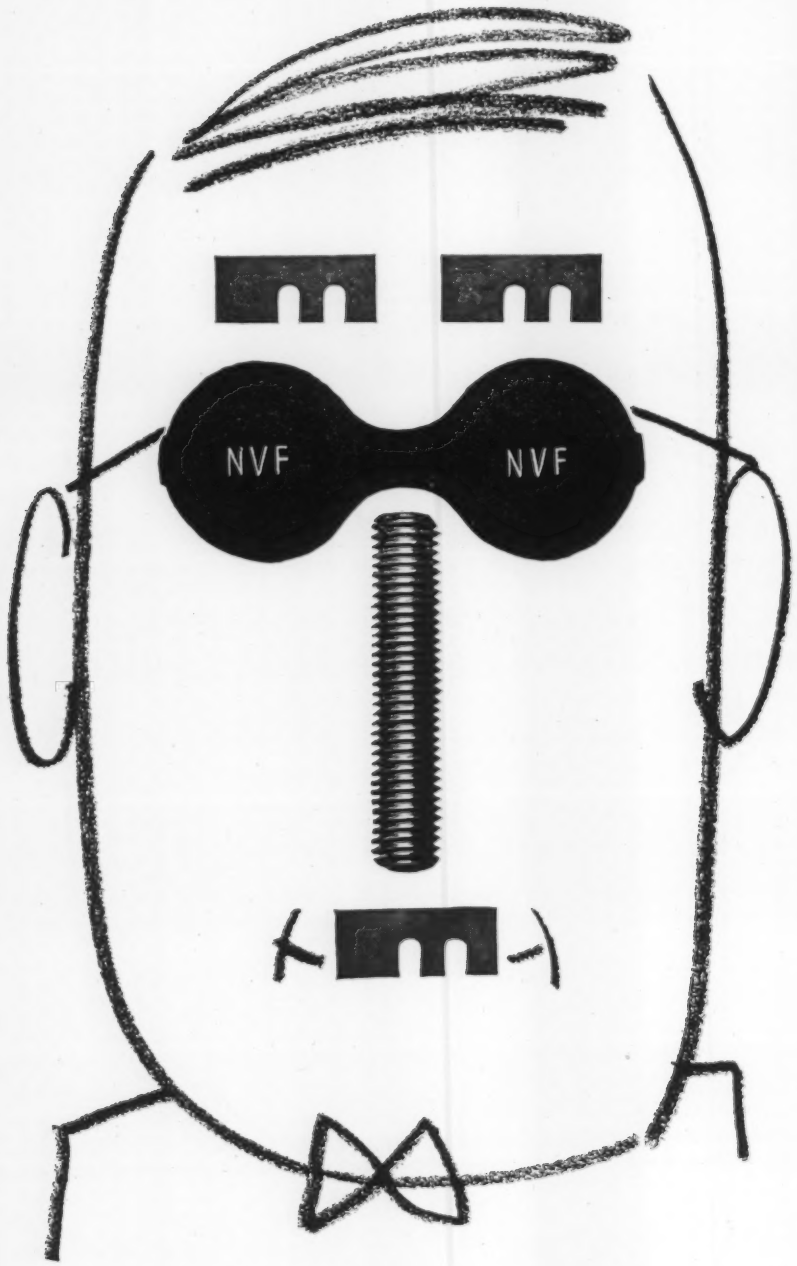
GENERAL ELECTRIC

GENERAL ELECTRIC'S MACHINE TOOL RELAY FAMILY

MACHINE TOOL RELAYS have front-connected terminals, can be wired from four directions for easier installation. Also, three keyhole slots simplify mounting the relay.



LATCHED-IN FORMS have a standard machine tool relay plus a latching mechanism, which mechanically holds the contacts closed to maintain the continuity of sequencing.



Why designers see everything they want in **National** fabricated parts

National gives them greatest design freedom with over 80 grades of basic materials—laminated plastic, vulcanized fibre and nylon.

National has the machines and skills to fabricate whatever customers design—from a 7″-deep draw in vulcanized fibre to a tiny 1/16″ screw machined bearing of PHENOLITE.

National offers unbiased recommendations and practical technical assistance based on years of experience in applying the broadest line of basic materials in the industry.

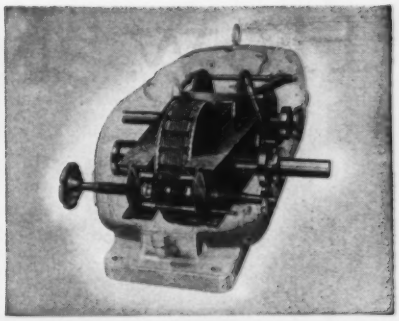
Get the facts on National Fabricated parts. See how you may profit . . . send for our free illustrated booklet on fabricated parts—"Management Decision for Profit." Address Department G-10.

NATIONAL VULCANIZED FIBRE CO. WILMINGTON 99, DELAWARE

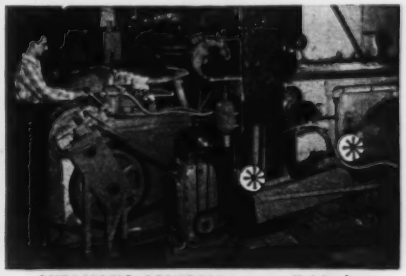
In Canada: National Fibre Company of Canada, Ltd., Toronto 3, Ontario

Circle 531 on page 19

THREE LINK-BELT P.I.V. DRIVES on this automatic production machine allow operator to select exactly the most efficient rpm for the tool and the metal he is working. He has precise, infinitely variable control of every operation.



ALL-METAL CONSTRUCTION, shown in phantom, means long operating life with little wear and maintenance.



AUTOMATIC CONTROLS are available for self-regulation of P.I.V. This jute slasher is controlled electronically.

COMPLETE DATA. Book 2274 suggests uses for P.I.V. in timing, synchronization, many other jobs. Book 2349 covers controls.

Variable speeds, unvarying accuracy

provided by stepless, positive Link-Belt P.I.V. drives

REGULATING machine and conveyor speeds . . . synchronizing and timing operations . . . metering material flow or controlling rotary motion —for countless jobs requiring infinitely variable control of rpm, all industry uses Link-Belt P.I.V.

Whereas ordinary variable speed drives depend on friction to transmit power, P.I.V. operates with an ingenious, slipless chain. It engages in radial grooves of two sets of wheels on input and output shafts. As the operator turns the control screw, one set of wheels closes . . . the other spreads. The self-tooth-forming chain automatically adjusts itself to the wheel diameters to provide desired ratio.

This grip assures positive selection of any speed from maximum to minimum settings—with any size loads and without interrupting machine operation. P.I.V. is unexcelled for accuracy, and its principle has been proved in many years of efficient service. Performance is quiet, trouble-free, unaffected by atmospheric conditions. To learn how it can extend the useful range of your machines, call your nearest Link-Belt office.

LINK-BELT

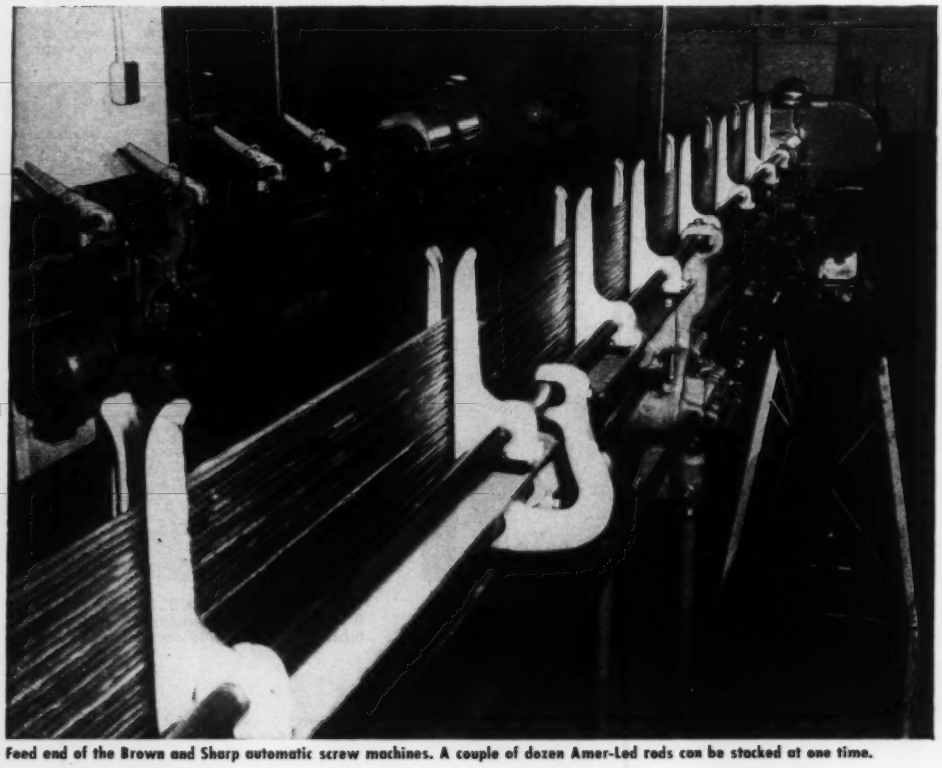
P.I.V. VARIABLE SPEED DRIVE

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,058

XUM

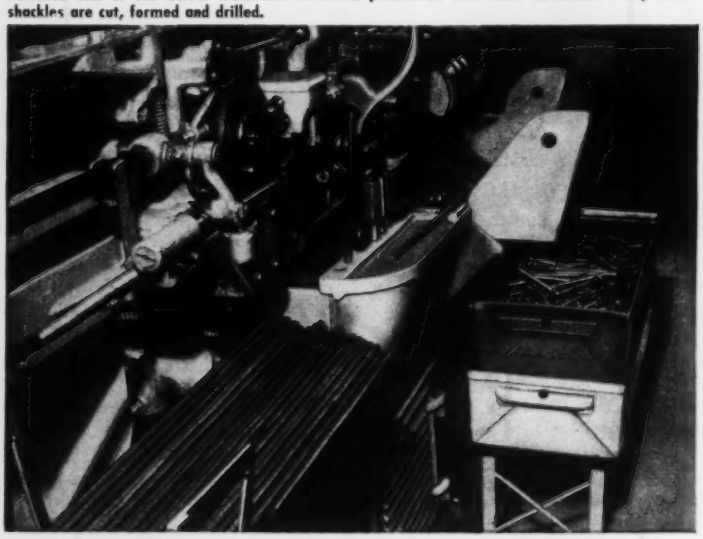
How "MASTER" put a

USS Amer-Led hikes



Feed end of the Brown and Sharp automatic screw machines. A couple of dozen Amer-Led rods can be stacked at one time.

Business end of the screw machines. Increased production was most noticeable here, where shackles are cut, formed and drilled.



Broaching is performed on this Zeh and Hahneman toggle press. Tool life is much greater since use of Amer-Led.

a padlock on costs...

: production 25% to 75%

When American Steel & Wire first developed Amer-Led free machining stock, it was suggested to Master Lock and it worked like a charm. Automatic screw machine production leaped 25% to 75% without any increase in tool wear! The finer grain structure of this new steel permitted more accurate cutting to closer tolerances, and there were fewer rejects, too.

Punch press production increased 15% to 20%, and was limited only by the ability of the operator to feed the machine. Although production was not increased in the broaching operation, tool life was increased.

Of course, this is the story of Master Lock Company. If *you* yearn for results like this, then get in touch with your AS&W representative. Ask about USS Amer-Led.

Schoolboys can identify a "Master" padlock with its unusual laminated steel case. The shackle is possibly the most important part. Miscreants try to twist it off with a crowbar, or sever it with hacksaw or rasp. Obviously, the shackle must be hard and free from brittleness after heat treatment; and during production it must be ductile and machinable.

The Amer-Led is stored as received—in steel strapped bundles. There's a type for most machining operations.

AMERICAN STEEL & WIRE
DIVISION, UNITED STATES STEEL
GENERAL OFFICES: CLEVELAND, OHIO.
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

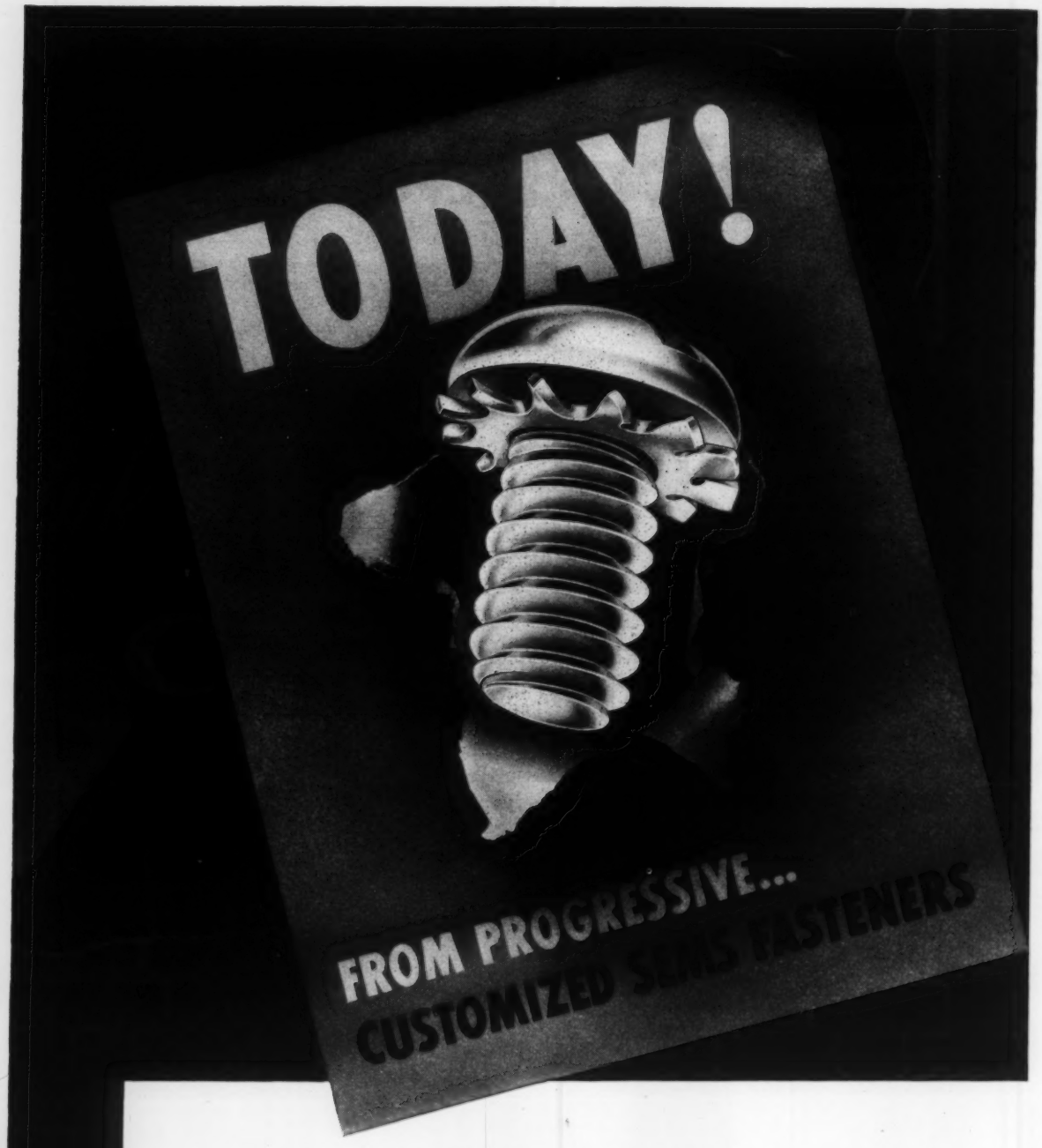
AMER-LED
SUPER-MACHINING
BARS

USS

UNITED STATES STEEL

Circle 533 on page 19

XUM

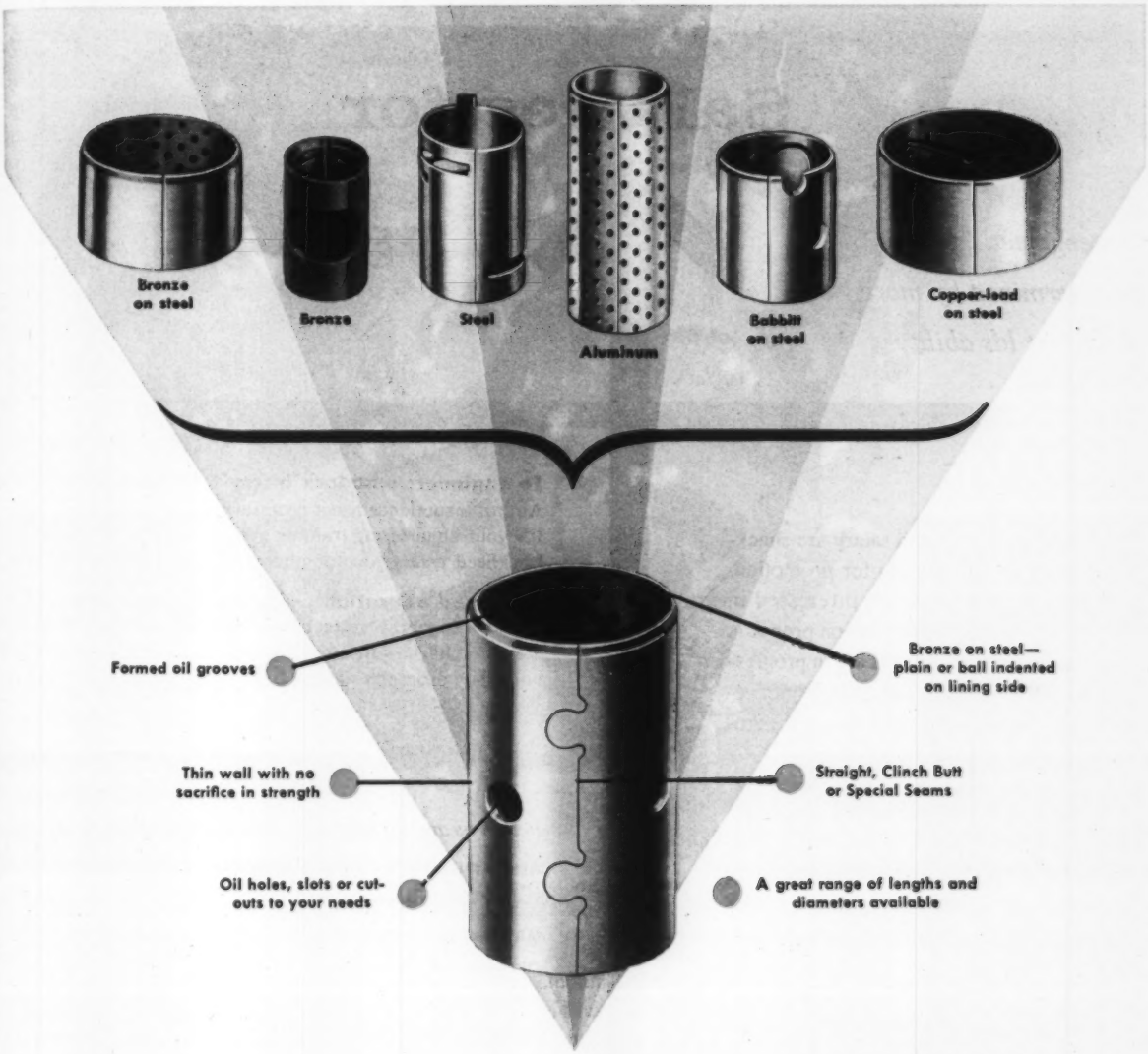


Now you can get from PROGRESSIVE Sems Fasteners with an extra customized touch — Sems Fasteners which are custom-made to your order. This means: (1) specifically made for you — not bin stock parts; (2) fast, custom-handling of every order; *plus* (3) the double economy of low initial cost *and* the savings in your assembly operations possible only with high precision, torsion-tested fasteners.

STANDARDS AND SPECIALS CUSTOMIZED FOR YOUR NEEDS

THE PROGRESSIVE MFG. CO.
Division of The Torrington Company
52 Norwood Street, Torrington, Connecticut

Circle 534 on page 19


Bronze on steel
Bronze
Steel
Aluminum
Babbitt on steel
Copper-lead on steel
Formed oil grooves
Bronze on steel—plain or ball indented on lining side
Thin wall with no sacrifice in strength
Straight, Clinch Butt or Special Seams
Oil holes, slots or cut-outs to your needs
A great range of lengths and diameters available

Bearing Performance with Bushing Economy

Any of these design features can be incorporated in our plain or bi-metal bushings. For many applications lower cost bushings provide the needed bearing characteristics at a distinct price advantage. We provide a complete engineering service. Address:

FEDERAL-MOGUL

DIVISION, Federal-Mogul-Bower Bearings, Inc.
11045 Shoemaker, Detroit 13, Michigan

BABBITT-LINED BEARINGS

BEARING-SURFACED THRUST WASHERS

SPACER TUBES

COPPER-LEAD BEARINGS

FEDERAL Mogul
SINCE 1899

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Circle 535 on page 19

XUM

Salaries for Engineers

An engineer's salary is determined by more than just his ability

All too often, ability and salary are shackled by lack of opportunity for promotion. For that reason, you'll be interested in Lockheed's diversified expansion program. Forty to fifty major projects are in progress continuously. Commercial and military activities cover virtually all phases of aeronautical endeavor.

The breadth and scope of this program means engineers have exceptional opportunity for promotion at Lockheed—simply because there are more supervisory positions to be filled with so many projects constantly in motion.

If your salary reflects lack of opportunity for promotion, why not look into opportunities presented by Lockheed diversification. It's worth discussing. Write or phone collect, if you possess an engineering degree or actual engineering experience. Address written inquiries to E. W. Des Lauriers or use the brief resumé form below. If you phone, call STanley 7-1241, Extension 6-2134.

To engineers who lack aircraft experience:
Aircraft experience is not necessary to join Lockheed. It's your engineering training and experience that count. Lockheed trains you for aircraft engineering—at full pay.

Advanced education program for engineers:
You can expand your technical knowledge and achieve advanced degrees through a variety of Lockheed-sponsored university programs that cost you little or nothing.

Positions are open on virtually all levels in fields of:

AERODYNAMICS
FLIGHT TEST ENGINEERING
MATHEMATICAL ANALYSIS
OPERATIONS RESEARCH
STRUCTURES
THERMODYNAMICS
WEIGHT

DESIGN
in controls, electrical, hydraulics, mechanical, power plant and structures areas.

ELECTRONIC SYSTEMS
in communications, countermeasures, fire control, navigation, radar and antenna design.

Lockheed Salary Facts

In the last three-and-a-half years Lockheed engineers have received blanket increases totaling 19%. This is in addition to merit increases granted engineers for individual achievement and promotion.

E. W. Des Lauriers, Dept. SE-39-10
Lockheed Aircraft Corporation, Burbank, California

Dear Sir:
Please send me your brochure detailing life and work at Lockheed.

Name

If you are an engineer, please state your field of engineering

Home street address

City and State Home phone

Circle 536 on page 19

Lockheed

AIRCRAFT CORPORATION
California Division
BURBANK, CALIFORNIA

MODEL K
Vane Type
Variable Volume
Pump
Pressures to 1000 psi
Up to 1200 rpm

RACINE®

WHY WASTE HORSEPOWER?

Hydraulic Power consumption is measured by the amount of oil pumped and the pressure needs of the circuit. Seldom do you need maximum output from the pump *and* top pressure throughout an operating cycle.

RACINE "Variable Volume" Pumps save horsepower because they pump only the volume of oil needed to operate the circuit.

By-passing of oil, heating, the cost of relief valves, excessive reservoir capacity, extra piping, all add to first cost and operating expense.

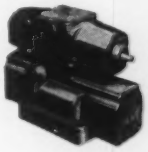
RACINE "Variable Volume" Pumps reduce these costs by simplifying your circuits. The Racine Model K Vane Type Variable Volume Pump shown above has a capacity of 70 gpm, with maximum pressure of 1000 psi at 1200 rpm. Other models in a full range of sizes from 5 to 70 gpm.

Why waste horsepower? Write today for complete information.

OTHER RACINE HYDRAULIC PRODUCTS

FLUID MOTOR
Vane Type
50 to 3500 rpm
Pressures to 1500 psi

PRESSURE BOOSTER
Pressures to 5000 psi
Ratios to 7:1



4-WAY VALVES
Twin Solenoid
Pilot Operated

RESERVOIRS
With Control Panel
Designed to your space
and circuit requirements

RACINE HYDRAULICS & MACHINERY, INC.
2073 Albert Street
RACINE, WISCONSIN, U.S.A.

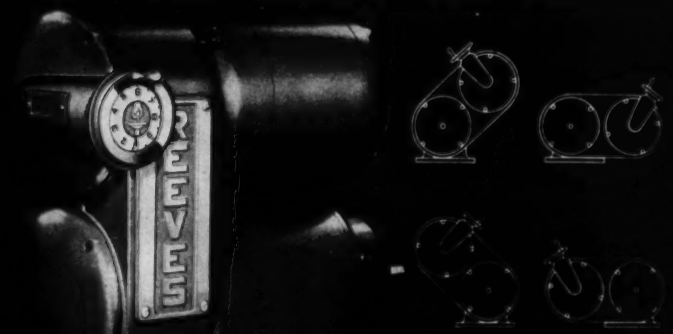
NFPA NATIONAL FLUID POWER ASSOCIATION

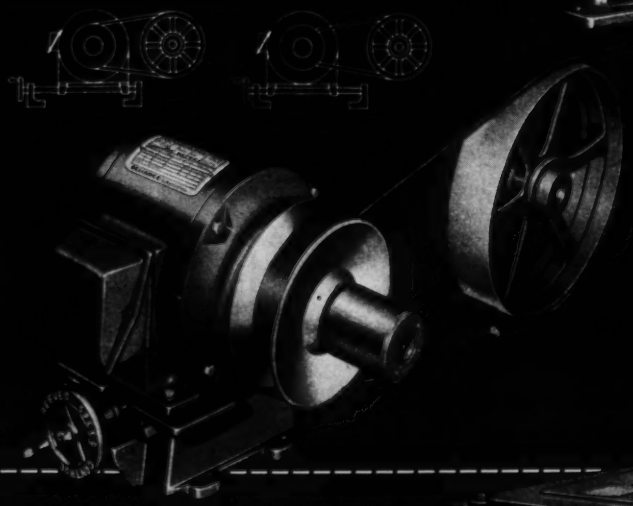
Circle 537 on page 19

REEVES®

the one name for all mechanical variable speed!

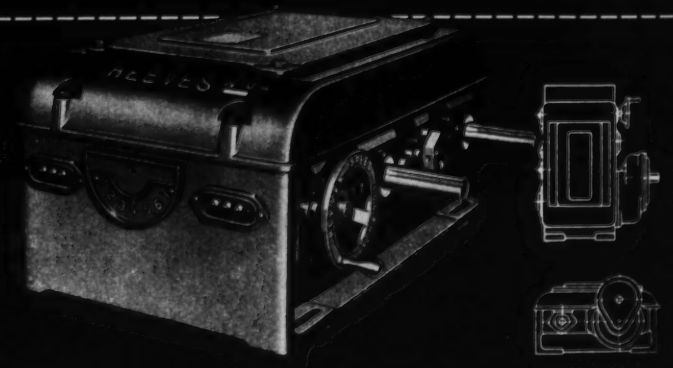
REEVES
Vari-Speed® Motodrive





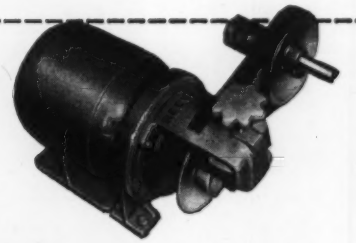
REEVES
Vari-Speed® Motor Pulley

REEVES
Variable Speed Transmission



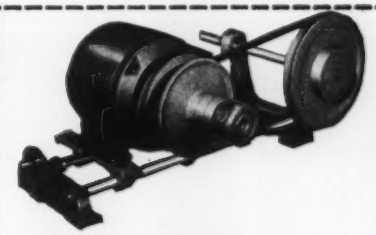
● The *complete line* in the industry is REEVES . . . adjustable speed drives and speed control for applications from ⅛ to 87 hp! The *proven* name is REEVES . . . years of trouble-free service in hundreds of thousands of installations—every industry! The *original* variable speed drive, REEVES is still the leader in its field!

Incorporate variable speed into the machines *you* design: widen the work range of the machines; insure your designs against early obsolescence; add the many operating advantages of accurate, instant speed control. Your REEVES representative—with wide and varied experience—will be glad to work with you for the *best* application . . . *best* results!



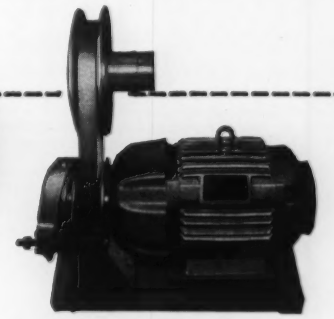
REEVES Flexi-Speed®

Two sets of adjustable discs with convenient shifting mechanism. Provides flexibility, economy to your equipment . . . easy to install. ½, ¾ and 1 hp. with 8:1 speed ratio.



REEVES Jr. Motor Pulley

Simplest form of variable speed control. 5 sizes from ⅛ to 1½ hp. capacity . . . ratios up to 2.75:1 in a speed range from 135 to 1965 rpm. Standard or countershaft bases for standard motors.



REEVES Vari-Spin®

A mill tested and proved unit to increase spinning efficiency and frame flexibility. 500 to 1450 rpm. range. Change speeds *with spinning frame in operation* . . . get required speed—in seconds!

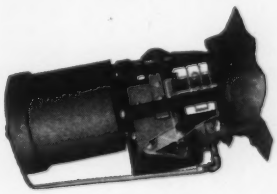
REEVES CONTROLS

Manual

Basic REEVES control on all units. "Speedial" handwheel, extended handwheel, hand chain and extended rod controls also available.

***Mechanical Automatic**

For Motodrive, Transmission. Simplest automatic control—requires shifting force sufficient to position control lever of speed changing mechanism.



Automatic (Pneumatic)

Motodrive application only. Cam-compensated design controls output speeds in direct proportion to instrument air signals.

Electric Remote

Push-button stations for single unit or battery of Motodrives, Transmissions or Motor Pulleys. AC or DC . . . full range of current characteristics.

*Also available in hydraulic or pneumatic type.

Individual bulletins—complete with rating tables and dimensions—are available for any of the above products by writing REEVES, Dept. H-26a, Columbus, Indiana.

Your REEVES representative will be glad to work directly with you. He's as near as your telephone . . . regional offices in 34 principal cities.

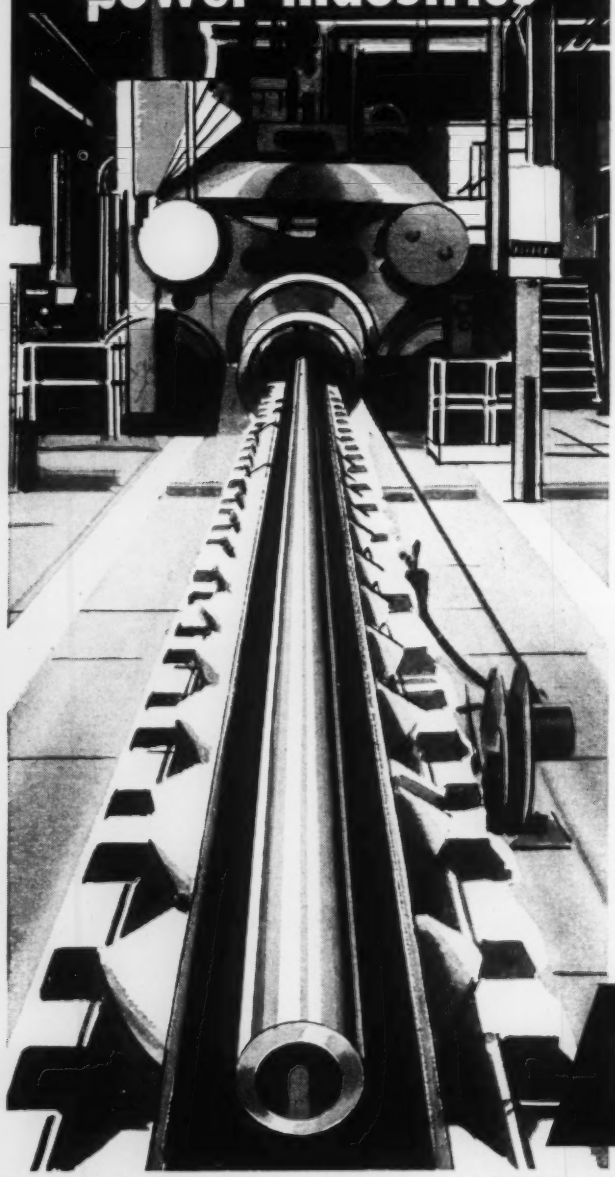
REEVES PULLEY COMPANY

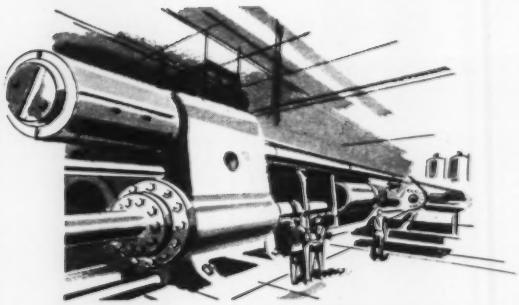
DIVISION OF **RELIANCE** ELECTRIC AND ENGINEERING CO.

COLUMBUS, INDIANA

Circle 538 on page 19

For longer life, higher performance in the petroleum, chemical and power industries





Corrosion-Resistant, Heat-Resistant EXTRUDED Steel Pipe

Curtiss-Wright's Metals Processing Division now offers the petroleum, petrochemical and power industries a line of high-quality, extruded steel tubular products to meet the most severe demands of modern processing. Inherent corrosion and heat-resistant properties of the steel alloys used are amplified by extrusion because the finished tube is produced with only one heat, in one pass of the giant 12,000 ton press . . . formed under compression in a matter of seconds without seams, in lengths up to 50 feet. Extra margins of resistance to corrosion and heat are built in easily by extruding heavier pipe wall thicknesses at no sacrifice in production speed. The most up-to-date quality control facilities, including ULTRASONIC TESTING, are employed in production.

Curtiss-Wright's extrusion facility is a specialty mill, ideally equipped for the production of special purpose, premium quality tubing. Conformance to A.S.T.M. specifications and other exacting standards is assured by an experienced engineering staff and the most modern metallurgical testing equipment.

When higher pressures and temperatures, or more corrosive service conditions demand more than the ordinary in large diameter pipe, let Curtiss-Wright serve you through the nearest Metals Processing Division Branch Office, or write to the Main Office address shown below.

71 Grider Street, Buffalo, New York

METALS PROCESSING DIVISION

CURTISS-WRIGHT CW

CORPORATION • BUFFALO, NEW YORK

ELECTRONICS • NUCLEONICS • PLASTICS • METALLURGY • ULTRASONICS • AVIATION

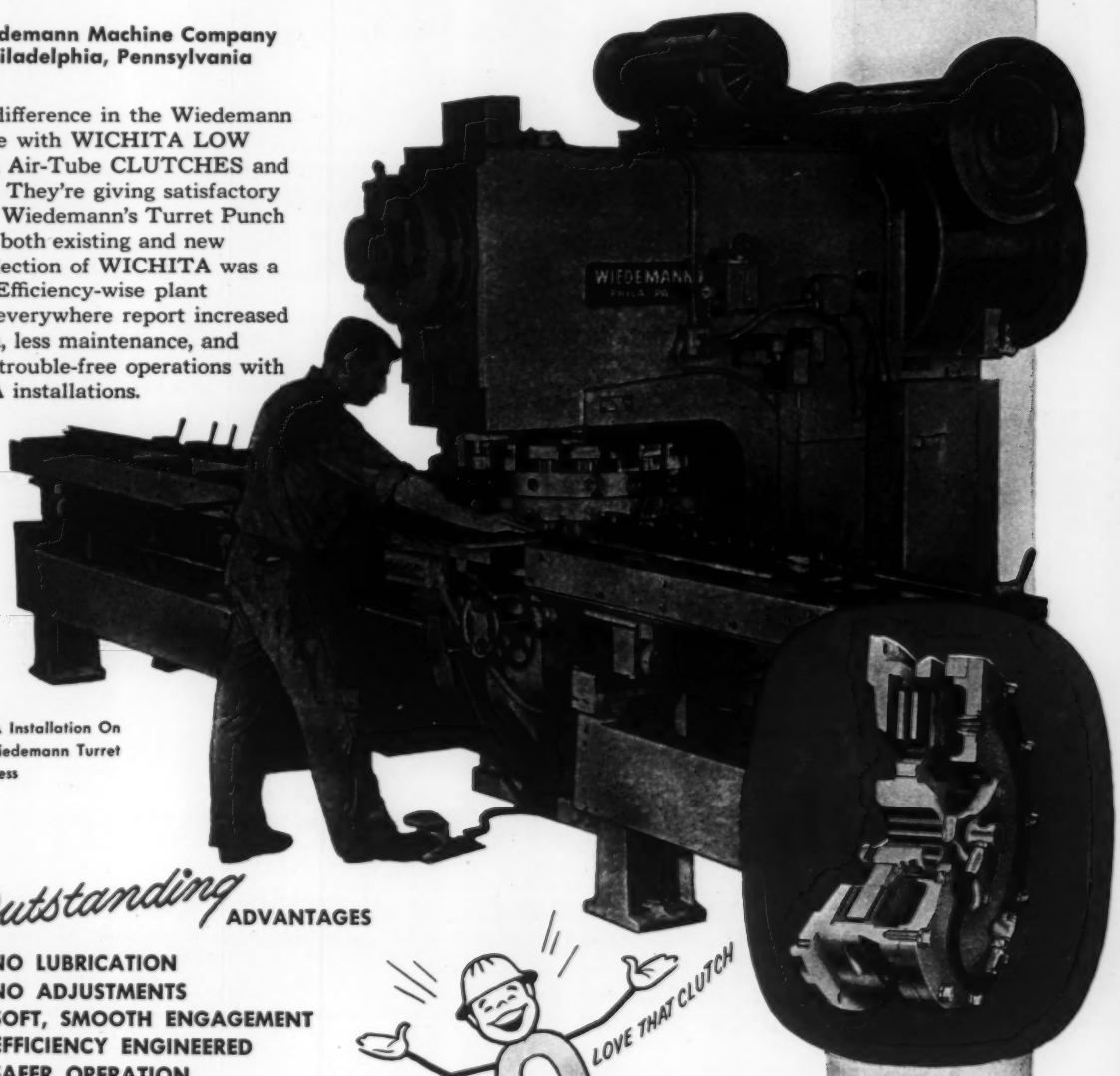
Circle 539 on page 19

"WE SELECTED WICHITA FOR...

Compact Design • Low Inertia • Maintenance-Free Operation."

Wiedemann Machine Company
Philadelphia, Pennsylvania

The big difference in the Wiedemann plant came with WICHITA LOW INERTIA Air-Tube CLUTCHES and BRAKES. They're giving satisfactory service on Wiedemann's Turret Punch Presses of both existing and new design. Selection of WICHITA was a wise one. Efficiency-wise plant operators everywhere report increased production, less maintenance, and smoother, trouble-free operations with WICHITA installations.



WICHITA Installation On RC-61 Wiedemann Turret Punch Press

OTHER *Outstanding* ADVANTAGES

- NO LUBRICATION
- NO ADJUSTMENTS
- SOFT, SMOOTH ENGAGEMENT
- EFFICIENCY ENGINEERED
- SAFER OPERATION
- MINIMUM SLIPPAGE
- POSITIVELY VENTILATED FOR COOLER OPERATION

Consult Your Nearest WICHITA Engineer for Complete and Detailed Information

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

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Hunt Tool Co., Houston, Texas
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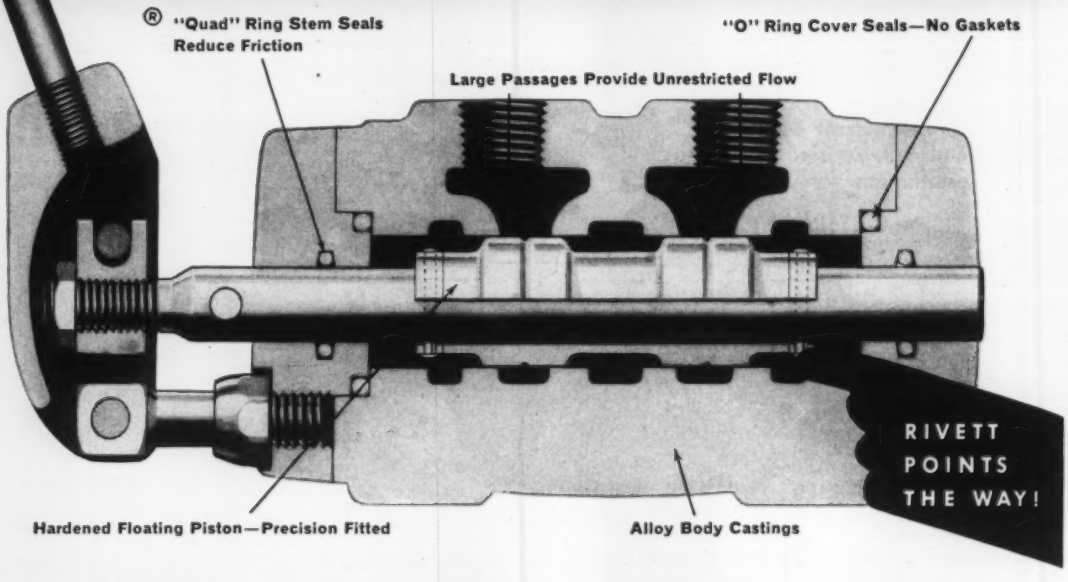
Circle 540 on page 19

XUM

No Stick! No Bind!


® "Quad" Ring Stem Seals Reduce Friction
"O" Ring Cover Seals—No Gaskets
Large Passages Provide Unrestricted Flow
RIVETT POINTS THE WAY!
Hardened Floating Piston—Precision Fitted
Alloy Body Castings

-with Floating Piston!

Valve Stem is Independent of Valve Bore in Rivett Hydraulic Pipe Mounted Valves

Other Fine Features Benefiting Your Circuit Design and Operation

- "Quad" Ring Stem Seals Reduce Friction
- Large Passages Provide Smooth, Full Capacity Flow
- Simple Design Assures Leakproof Operation
- Opens And Closes Smoothly, Positively
- Operates Multi-Million Cycles At 1500 P. S. I.

1607 VALVE SELECTIONS!

Types: Hand, foot, cam, solenoid, pilot, oil pressure, air pressure, flow control, check, deceleration, relief, unloading, sequence, counterbalance.

Sizes: ¼", ⅜", ½", ¾", 1", 1¼", 1½".

Actions: Standard, spring-return, spring-centered, ball detent.

Mountings: Pipe mounted; panel mounted.

P.S.I.: 1500 P.S.I.; 3000 P.S.I. oil service.

Piston designs for any circuit.

RIVETT, INCORPORATED • Dept. MD-10
Brighton 35, Boston, Mass.

THE BETTER YOU KNOW HYDRAULICS THE BETTER YOU LIKE

Get Catalog No. 204 to aid your circuit design. Complete drawings, specifications, cut-away views, tables, diagrams!

® "QUAD RING" is the registered trademark of the Minnesota Rubber and Gasket Company.

RIVETT
"100" HYDRAULIC VALVES

save money, minutes, metal

with B&W MECHANICAL TUBING

CARBON • ALLOY • STAINLESS

Countless hollow parts and products now being made from solid stock can be fabricated more economically from tubing. The hole is there, eliminating heavy drilling with all its attendant waste. And the wide range of sizes, shapes, analyses, finishes and heat-treated conditions in which B&W Mechanical Tubing is available, make it a semi-finished product in itself — reduce all your machining operations to the minimum.

Get the facts on savings from Mr. Tubes, your link to B&W and your local B&W tubing distributor.

Write for Guide to the Use of Seamless Mechanical Tubing, Technical Bulletin 340.

The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

B&W TUBULAR PRODUCTS DIVISION

TA-5031 (G)

Seamless and welded tubular products, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels

Circle 542 on page 19

TOMORROW:

A standard motor that can

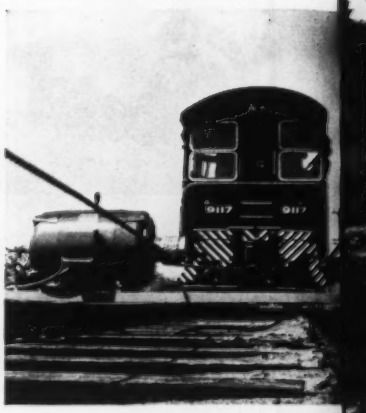
The new Life-Line A is another step closer

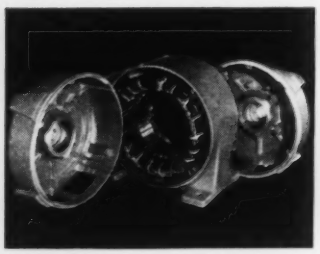
One of the principal causes of motor failure today is overloading. Right now Westinghouse is working on motor designs that will someday result in a motor that can survive any overload.

This picture shows a 15-hp Life-Line "A" motor pulling a quarter of a million pounds of locomotive on New York Central tracks near Buffalo. It's simply a dramatic way of showing the progress Westinghouse has made toward better overload protection. Improved insulation, frame construction and bearing design give the Life-Line "A" better protection against overloads than ever before. It's industry's closest approach to a standard motor that can withstand any overload condition.

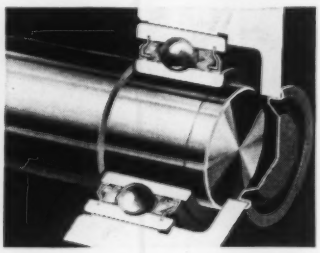
Your Westinghouse sales engineer is ready to tell you about many other reasons why the Westinghouse Life-Line "A" is industry's most advanced and preferred motor. Call him today.

J-21925





New exclusive Bondite* impregnating varnish, partner to new Bondar* and Mylar† insulations, guarantees complete resistance to the heating effects of heavy overloads as well as motor contaminations.



Exclusive Life-Line "A" prelubricated bearing features a new 4-way seal and completely excludes the three main causes of bearing failure: (1) contamination, (2) overgreasing, (3) wrong grease.

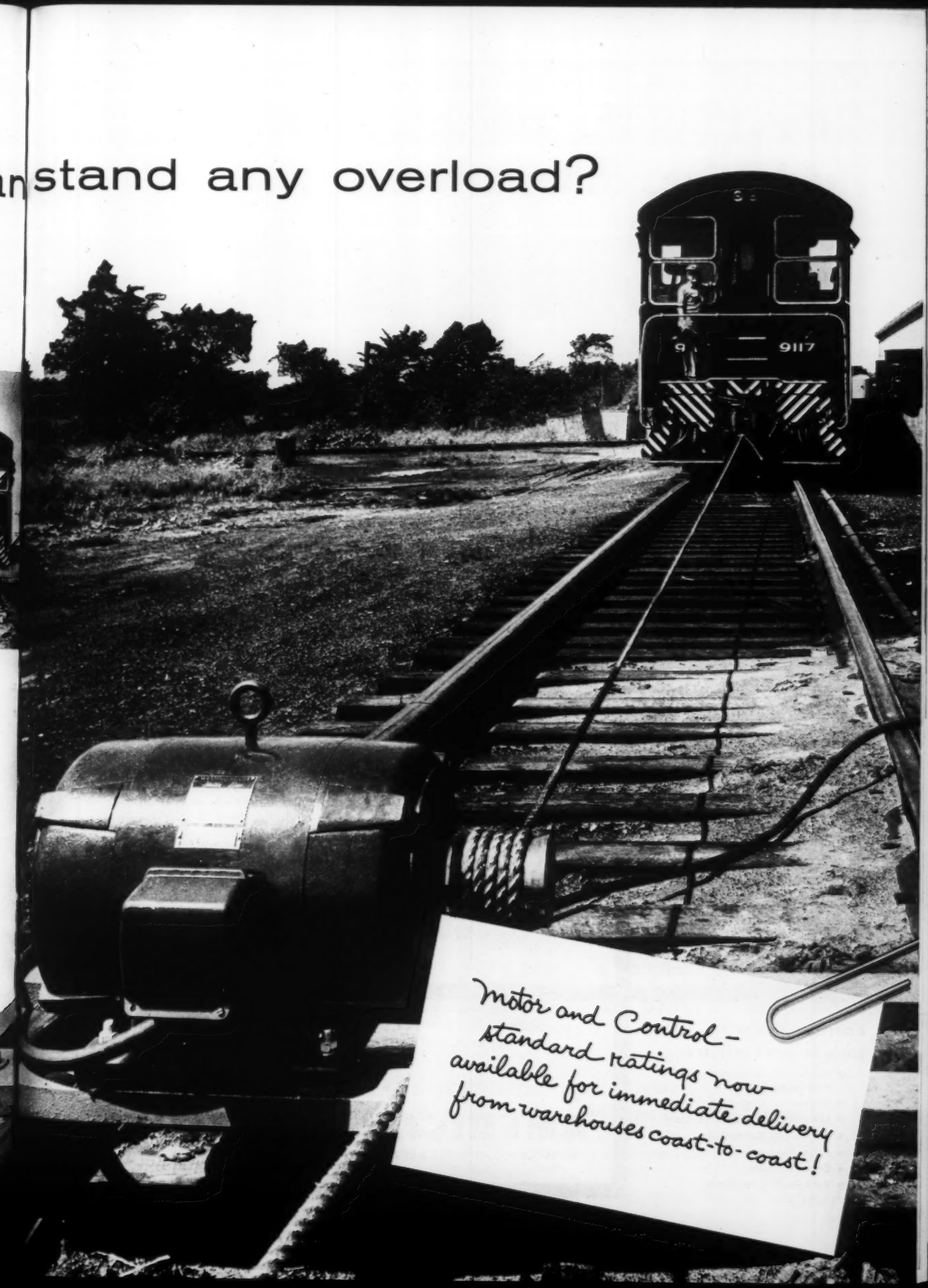
*Trade-Mark †Du Pont Registered Trade-Mark

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING **TODAY!***

Circle 543 on page 19

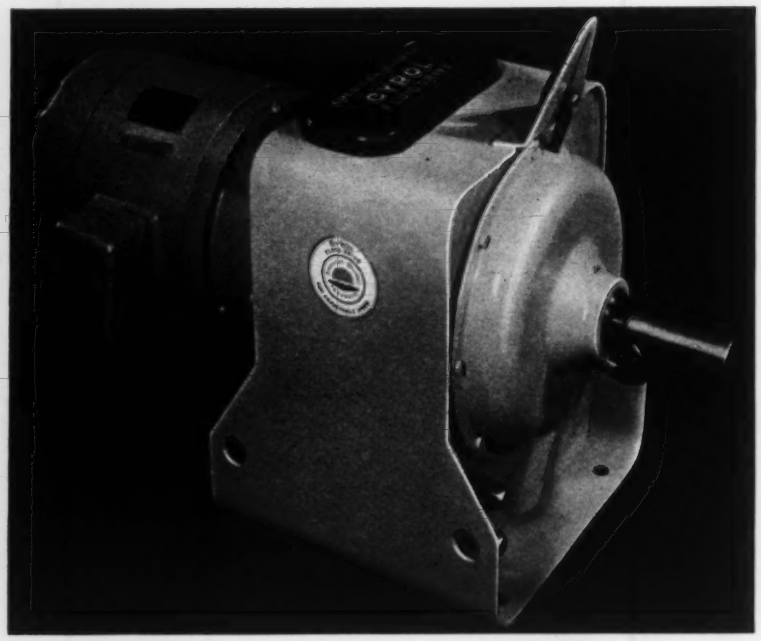
an stand any overload?



Motor and Control –
standard ratings now
available for immediate delivery
from warehouses coast-to-coast!

XUM

Now! Get the advantages of Gýrol® Fluid Drives in lower horsepower range



Type VS, Class 2 Gýrol Fluid Drive for 1- to 800-hp applications.

With the addition of new sizes in the lower horsepower range, you now have a *complete line* of Type VS, Class 2 Gýrol Fluid Drives from which to select – 1 hp to 800 hp, speeds to 3600 rpm!

These compact, self-contained units offer unlimited application possibilities, because of their important benefits: adjustable, stepless speed control; reversible while in motion; 5 to 1 speed range; no-load starting; complete shock absorption; remote, manual, or automatic control; quiet operation.

For full information on the complete Type VS, Class 2 Gýrol Fluid Drive line, contact our nearest branch office. There is one in every principal city.

Typical Applications:

PUMPS, AGITATORS, MIXERS

CONVEYORS, CABLE & ROPE MACHINERY

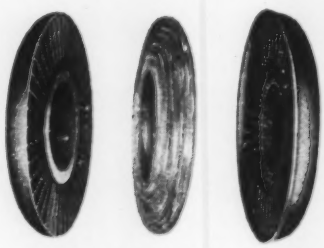
FANS AND BLOWERS

CENTRIFUGAL COMPRESSORS

PAPER AND PRINTING MACHINERY

TEXTILE MACHINERY

Simple design, flexible operation



Runner Vortex of Oil Impeller

Gýrol Fluid Drive provides a simplicity of design and a flexibility of operation no other method of power transmission offers – plus an inherent safety factor. Operates on hydro-kinetic principle, using vortex of oil to transmit power from driving to driven machinery. Power is transmitted smoothly, evenly, efficiently, without shock.

American Blower products serve industry

- Air Conditioning, Heating, Ventilating Equipment
- Mechanical Draft Equipment
- Industrial Fans and Blowers
- Centrifugal Compressors
- Gýrol Fluid Drives
- Dust Collectors
- Refrigerating Machines

AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO

Division of AMERICAN-Standard

AMERICAN **BLOWER**

Circle 544 on page 19

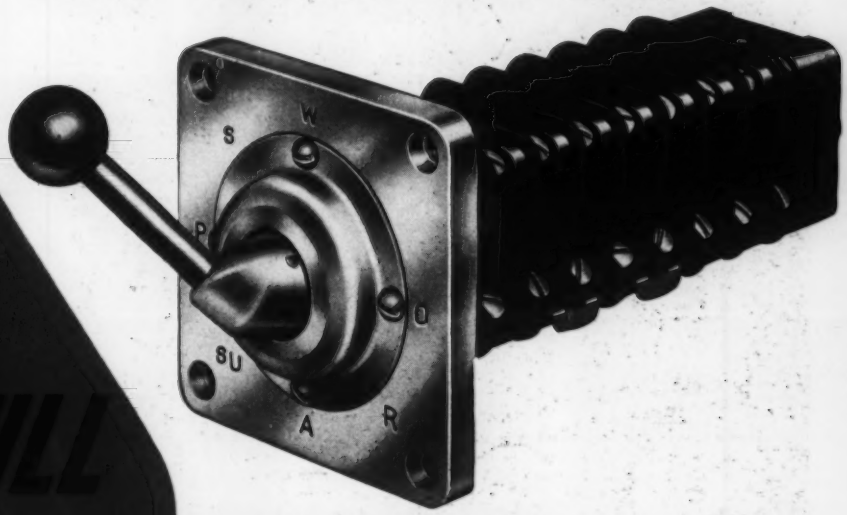
Circle 545 on page 19→

This is IT!

ONE POINT of CONTROL for ANY APPLICATION

with the

ARROW AH HART



PUSH-PULL SELECTOR SWITCH

SAVES APPARATUS AND SPACE . . . PROVIDES SIMPLIFIED CONTROL

COMPARE
A 2-SPEED REVERSING LATHE
8 OPERATIONS

involving spindle motor, coolant motor, brake and a "Safe" position.

CONVENTIONAL CONTROLS	AH "PPS"
6 Magnetic Units	1 Magnetic Unit
7 Push Buttons	1 "PPS" Switch
11 UNITS . . .	SAVED

COMPARE
A DRY CLEANING MACHINE
8 OPERATIONS

involving fan, pump, washing and extractor motors and "Automatic" and "Off" positions.

CONVENTIONAL CONTROLS	AH "PPS"
6 Magnetic Units	3 Magnetic Units
1 Timer	1 Timer
14 Push Buttons	1 "PPS" Switch
16 UNITS . . .	SAVED

COMPARE
AN AUTOMATIC BAKELITE PRESS
8 OPERATIONS

involving a choice of jogging for each separate function or completely automatic cycling.

CONVENTIONAL CONTROLS	AH "PPS"
6 Magnetic Units	2 Magnetic Units
1 Timer	1 Timer
9 Push Buttons	1 "PPS" Switch
12 UNITS . . .	SAVED

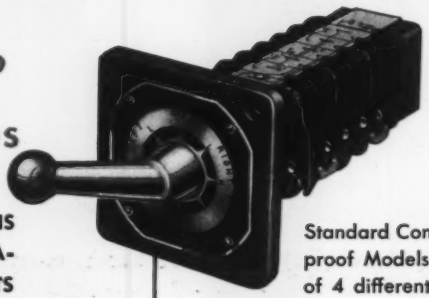
THE SIMPLE ANSWER TO YOUR COMPLEX CONTROL PROBLEMS

REDUCES CONTROLS REQUIRED • SAVES SPACE and WEIGHT • IMPROVES LAYOUT and APPEARANCE • ADDS FLEXIBILITY, VERSATILITY • PROVIDES MAXIMUM SPEED, EASE and SIMPLICITY of OPERATION • FOOLPROOF, PROTECTS OPERATOR and EQUIPMENT • ASSURES PEAK PERFORMANCE

TURN THE PAGE FOR AN ELECTRICAL DESCRIPTION and OPERATIONAL FEATURES

XUM

Control TAILORED TO YOUR EXACT NEEDS



STANDARD CONSTRUCTION WITH CAST LEVER HANDLE ILLUSTRATED

Standard Construction or Oil and Weather-proof Models are available with a choice of 4 different Handle Types.

— THE ARROW-HART "PPS" SWITCH IS CUSTOM BUILT TO YOUR SPECIFICATIONS FROM STANDARD COMPONENTS

What the "PPS" does

A SINGLE "PPS" UNIT PROVIDES SINGLE-POINT CONTROL . . . involving practically any desired circuit arrangement.

THE "PPS" REDUCES THE NUMBER OF CONTROLS REQUIRED

— because it is the ***ONLY*** pilot device required for practically all installations.

— because the "PPS" makes a single ***MAGNETIC*** control (starter, contactor etc.) do the work of many.

Here IS THE BASIC OPERATING PROCEDURE SIMPLE AS A-B-C

A **PUSH and TURN TO SELECT . . .** The operator must first push the handle — opening all circuits and disconnecting all controls. The handle can then be turned to any desired position; this selects the correct circuits for the required function. Any number of unwanted, intermediate functions can be passed without energizing their circuits.

B **PULL TO START . . .** With the handle in the desired position, the handle is pulled to start the operation — the same as actuating a conventional "Start" button.

C **PUSH TO STOP . . .** Pushing the handle immediately stops the operation. "PPS" single-point control is safer in emergencies because there is never a delay to find the right button.

Tested, Accepted...and Acclaimed

Leading manufacturers and designers of new equipment, plant engineers and maintenance men, and operators everywhere who have worked with and know the "PPS" are universally sold on its benefits. Although it is revolutionary and relatively new, the "PPS" has been thoroughly tested on innumerable installations and found OUTSTANDING.

IT WILL PAY YOU TO KNOW MORE ABOUT THE ARROW-HART "PPS" SWITCH

This new concept in motor control can help solve your present tough control problems . . . and help you build peak performance into your new designs. Use the coupon, attached for your convenience, to send for completely descriptive literature including a sample Target Sheet for plotting your circuit requirements.

Industrial Control Division
THE ARROW-HART & HEGEMAN ELECTRIC CO.
103 Hawthorn Street, Hartford 6, Conn.

Please send me ☐ complete information about the Push-Pull Selector Switch. ☐ Also the A-H Design Story folder featuring Type "RA" Magnetic Motor Controls.

NAME _____

CO. NAME _____

POSITION _____

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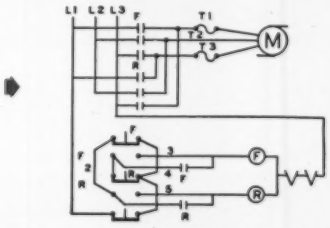
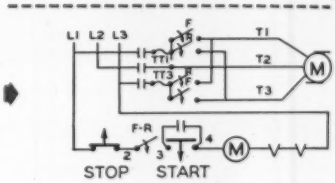
How the "PPS" works

To explain the action of the "PPS", let us look at an example; the simplest possible is the standard reversing of a motor. This example will show how the required number of magnetic units is reduced and how single-point control will serve for any number of operations.
While your own actual control application may be more complex than this example, it will simply entail using enough additional circuits to accomplish the required combinations of load and control hook-up.

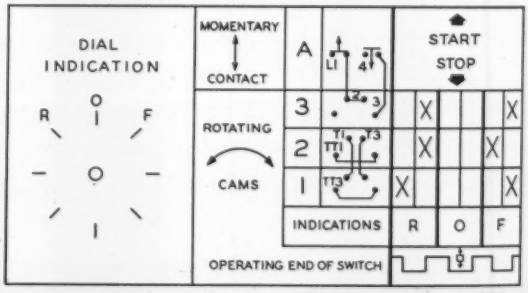
CONVENTIONAL CIRCUIT . . . This diagram shows the familiar type of reversing circuit. 3 push buttons and 2 magnetic units are required.



"PPS" CIRCUIT . . . Here the Rotating Cam Sections of the "PPS" select the circuit, and the Momentary Contact Sections operate the motor as desired. The diagram also shows the symbol used for "Stop" by pushing and "Start" by pulling. Only 1 *magnetic unit* and 1 pilot device, (the "PPS"), are required.



THE "TARGET SHEET" . . . shown here in abbreviated form, is the means by which your control requirements are translated into a diagram for the construction and wiring of a "PPS" Switch. A wiring diagram strip shield is visible from the top of every switch you buy indicating the terminals and all internal and external connections on the "PPS".



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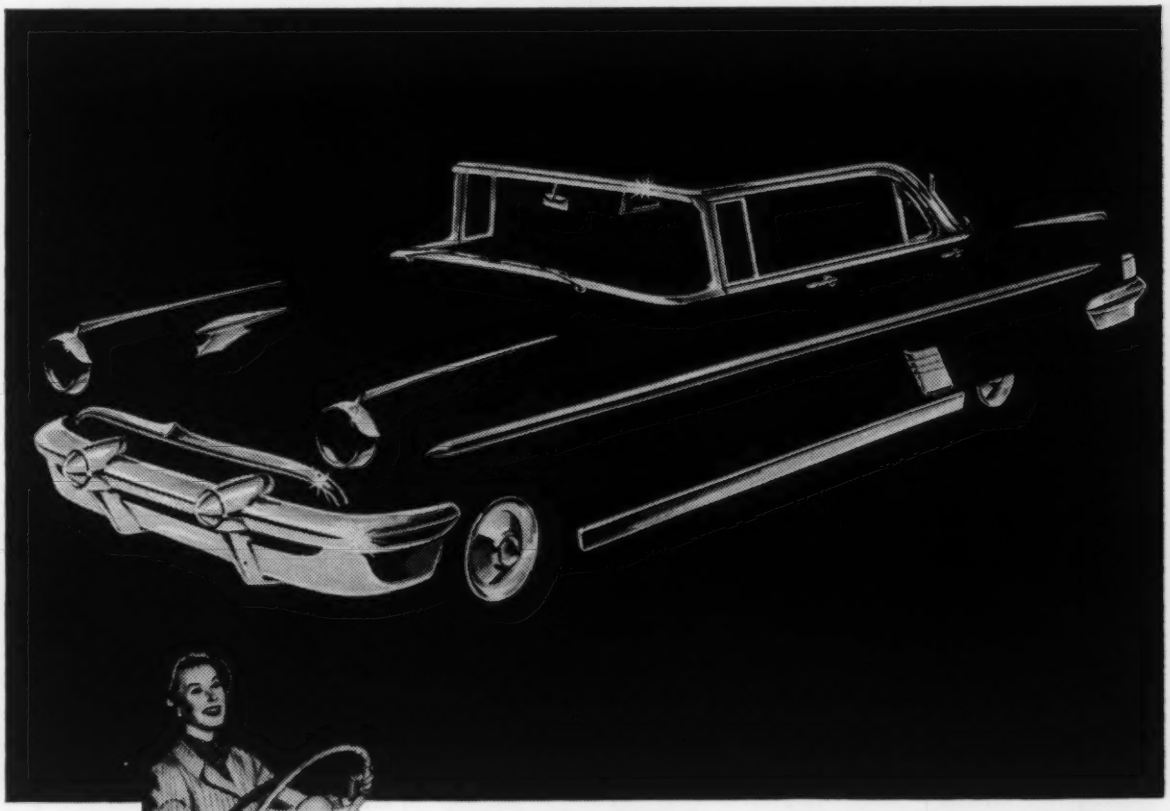
INDUSTRIAL CONTROL DIVISION
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
HARTFORD 6, CONN., U.S.A.

Offices, Sales Engineers or Warehouses in: Atlanta, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Columbus, O., Dallas, Detroit, Houston, Los Angeles, Milwaukee, Minneapolis, New York, Philadelphia, St. Louis, San Francisco, Syracuse, In Canada: Arrow-Hart & Hegeman (Canada) Ltd., Mt. Dennis, Toronto.

XI

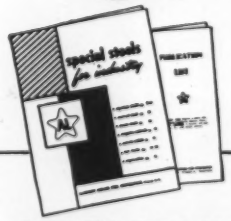
Bright good looks that **WON'T** *wear off ... value that* **CAN'T** *wear out!*



Stainless steel brightwork (ask about it on the car *you* buy!) has much more than surface attractiveness. It has built-in, *timeless* beauty. Beauty that goes all the way through—doesn't scratch off or rust off. Beauty that lasts—outlives the car itself. And beauty that's practical . . . requires no weary polishing, just ordinary washing.

In fact, *wherever* it's used, AL Stainless delivers something extra in good looks, strength, service life and resistance to rust and wear. Even where its first cost is higher (and that's not always the case) stainless steel usually costs much less in the end, because it lasts so much longer than other materials.

AL Stainless Steel has given thousands of products a competitive edge: all sorts of products, from safety pins to railroad trains. Maybe there's a place in *your* business where it can boost sales appeal or reduce costs. Let's help you look. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*



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Circle 546 on page 19

Where Dependability is Vital...

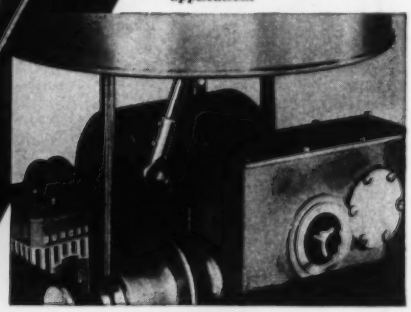
HEIM *Unibal* ROD ENDS

at each end of the linkage connecting the bellcrank and the piston wrist pin, operate the all-important air pump in this Technicon-Huxley Chest-Abdomen Respirator. In this application, the Heim Rod Ends eliminate all bind in the reciprocating piston and all noise and play, even after long and constant use.

This respirator, made by Conitech, Chauncey, N. Y., is completely portable and is an improvement over the iron lung, as it leaves the upper and lower extremities of the patient free, permitting sitting-up, exercising of the limbs, and nursing care. Constructed for long-time continuous operation, the power unit is a positive displacement piston mechanism, operated by the Heim Rod Ends, which delivers a volume of about 1100 cu. in. per stroke.

Heim has an informative, illustrated catalog of Unibal Bearings and Rod Ends as well as all other Heim bearings. Send for your copy and use Heim's engineering service for any linkage problem.

THE HEIM COMPANY
FAIRFIELD, CONN.



The single ball principle of the Heim Unibal corrects misalignment, reduces friction, and offers smoother operation and greater freedom of movement in any application.

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Circle 548 on page 19

SQUARE D's NEW TERMINAL BLOCKS

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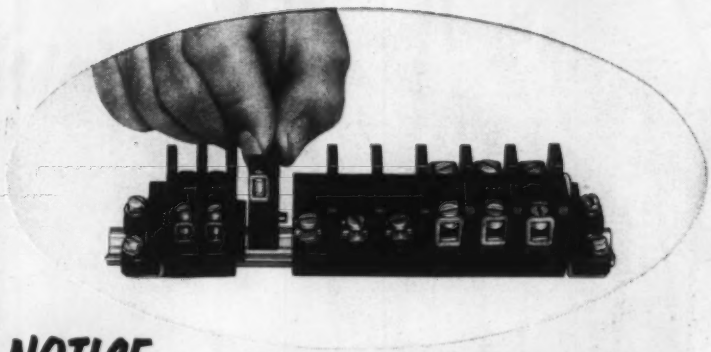
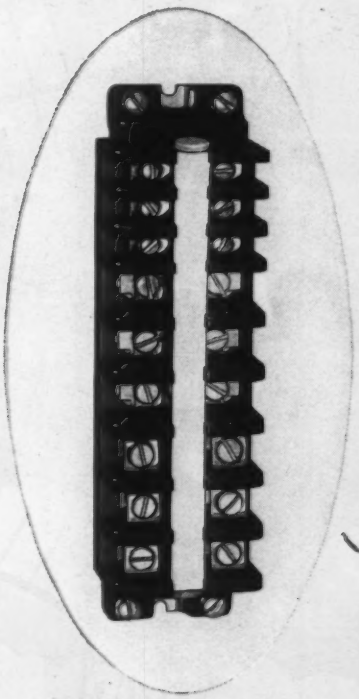
SQUARE D COMPANY

TERMINALS IN SAME SPACE!

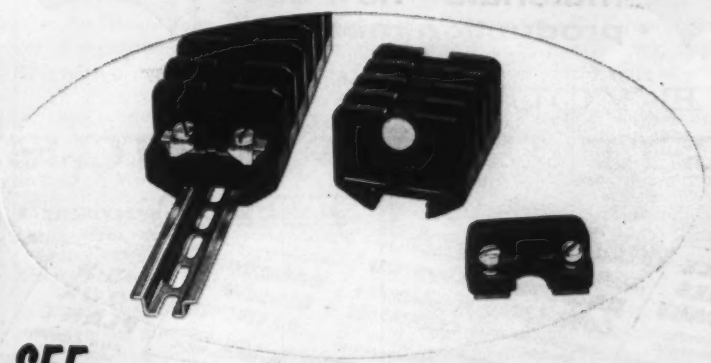
MORE FLEXIBILITY, TOO!





NOTICE (ABOVE) how little space is required to remove or add a Square D channel-mounted terminal block to the completely assembled unit. Especially important for a *QWIK CHANGE* when an additional terminal must be inserted into grouping.

LOOK (AT RIGHT)...all sizes can be mounted on same channel... 25 ampere pressure wire connectors, 25 to 50 ampere box lugs... all can be interlocked together. Terminals available in kit form to "do it yourself" or factory assembled to standard specifications.



SEE ...there is only one perforated channel required for either weld or screw-on mounting...available in standard lengths that can be cut "on the job" to fit any length requirement. Eliminates stocking varying sizes.

ASK YOUR SQUARE D FIELD ENGINEER

or Write for

Bulletin which covers details on Channel-Mounted Terminal Blocks. Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.

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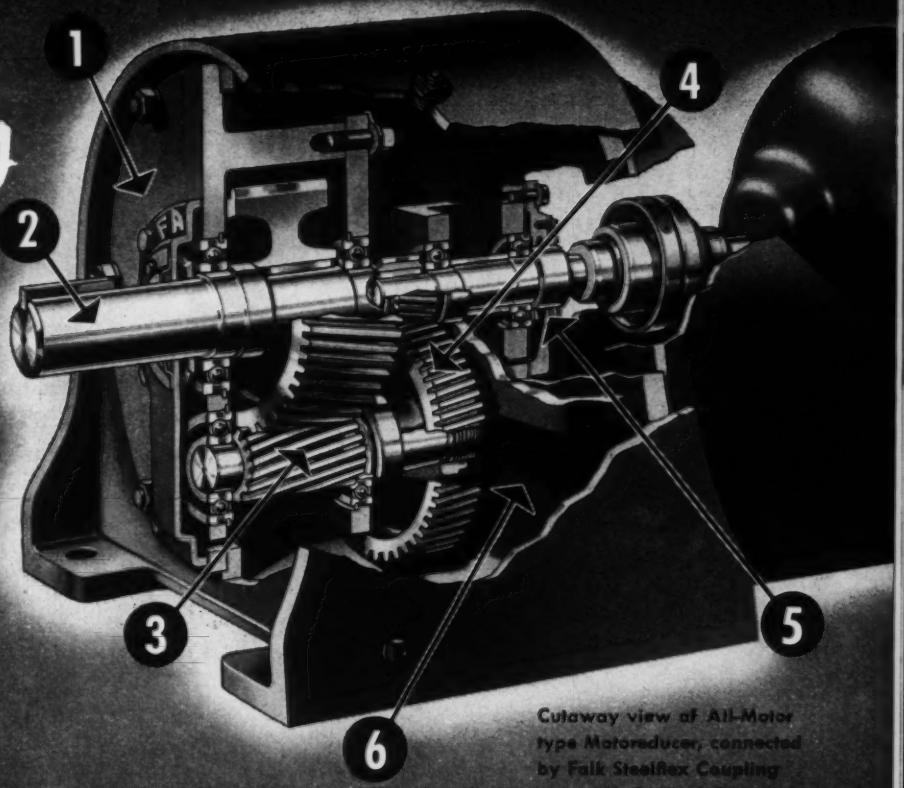
Circle 550 on page 19

Here's the inside story—



Cutaway view of All-Motor type Motoreducer, connected by Falk Steelflex Coupling to standard NEMA frame motor

WHY Falk Motoreducers give better service—have longer life

Here is the "inside story" behind the all-steel All-Motor type FALK Motoreducer's universal reputation as a gear drive unmatched in quality, efficiency, dependability, ease of maintenance and long life. These "In-built" factors are—

1 ALL-STEEL HOUSINGS. Rugged, strong, rigid... all parts are manufactured from heavy steel plate, formed and welded in the Falk Weld Shop.

2 LARGE OVERHUNG LOAD CAPACITY. Large shafts, oversize bearings... rigid mountings with wide bearing spans to handle maximum applied loads.

3 PRECISION GEARING. Heat-treated alloy steel gearing, precision cut and shaved after heat treatment to eliminate distortion. Quiet, crown-shaved pinions.

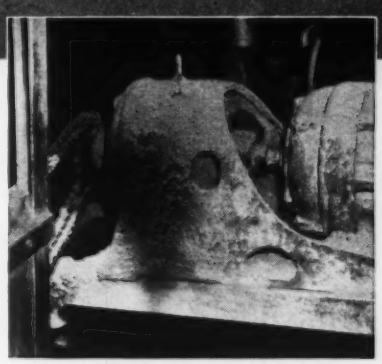
4 EXTRA-CAPACITY GEARING. Special extra-capacity gear-tooth form with larger contact area gives greater strength, higher load-carrying capacity.

5 SEALED HOUSINGS. Splashproof, dustproof, oil-tight construction. Dual closures and one-way vents keep oil in, dust and moisture out.

6 POSITIVE LUBRICATION. Large sump capacity... oiltight construction assures clean lubricant... revolving elements lubricated by direct dip.

When you buy or specify the All-Motor type FALK Motoreducer, you get all these—plus the tremendous advantage of full interchangeability of motors. Switch motors as desired—use any make, style or type of standard foot-mounted motor within the unit's AGMA rating—with a minimum of difficulty or "down time."

Available in sizes up to 75 hp—*with or without motor*—from convenient factory, field or distributor stocks, from coast to coast. **Write for Bulletin 3100.**



60,000 HOURS WITHOUT A FAILURE!

Sixty thousand hours is a lot of hours—but the FALK Motoreducer in the unretouched photo above has served that long without failure or need of repair.

This 3 hp unit is one of over 60 FALK Motoreducers in daily service in an Eastern plant of a large milling company, whose president says, in part:

"One of the main advantages of FALK Motoreducers is their adaptability to any motor. Reducers and motors can be easily interchanged.... Our service records confirm the wisdom of our choice of FALK equipment as our standard."

FALK ...a good name in industry

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

MANUFACTURERS OF

- Motoreducers
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- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

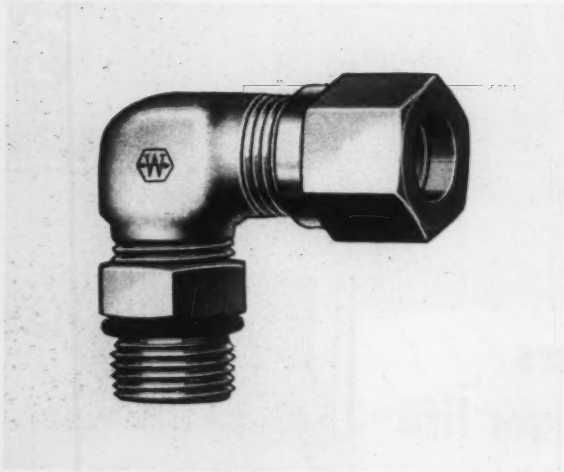
Circle 551 on page 19

XUM

(Advertisement)

Important Facts About The New Ermeto® Hydraulic Tube Fittings

► **The Weatherhead Company, Fort Wayne Division, Fort Wayne, Indiana, announces a new type 7000 Series ERMETO high-pressure S.A.E. flareless, straight-thread hydraulic tube fitting. Designed to accommodate minimum close coupling. Treated with "WEATHERCOTE" finish to resist nonflammable hydraulic fluids as well as petroleum base fluids.**



THE new 7000 Series Ermeto line meets the new standards as set by the S.A.E. This new fitting is an adaptation of the well-known Weatherhead Ermeto design used extensively in military, construction and industrial equipment for hydraulic and pneumatic systems.

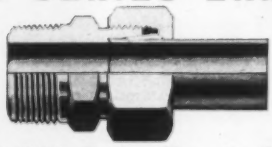
(A) Designed to accommodate minimum close coupling. Installation can be made in seconds with standard bench tools. The cutting and bowing action of the sleeve assures an unyielding leakproof seal . . . a joint that can be disassembled and reassembled time and time again.

(B) New phosphate finish (identified as "Weathercote" is resistant to nonflammable hydraulic fluids as well as petroleum base fluids. Even without lubrication, "Weathercote" finish reduces torquing to preset or reset sleeve as compared to cadmium plating.

(C) Designed for use with the new S.A.E. "0" ring boss, this new line withstands higher operating pressures without the use of back-up rings; results in less "0" ring distortion, longer "0" ring life. The new type "0" ring seal is also designed for air application and tested to operate at temperatures from —65° F. to 212° F.

Specifically designed for high-pressure systems, the new Ermeto tube fitting is stocked in 31 different styles and in sizes from $\frac{1}{8}$" to 2". Simplicity of design and ease of assembly simplify field replacement, reducing downtime to a minimum.

8000 SERIES ERMETO®



Weatherhead 8000 Series Ermeto flareless tube fittings in steel or stainless steel . . . available in standard styles and sizes for all hydraulic and pneumatic high-pressure applications. Industry's leading high-pressure line connector.

The Weatherhead Company, Dept. AB-10, Fort Wayne Division, 228 West Washington Blvd., Fort Wayne, Indiana. In Canada: The Weatherhead Co., Ltd., St. Thomas, Ontario.

They Will Stand Close Inspection

The young man at the hobbing machine is merely giving his work an appraising look. Detailed inspection will come later, and it is safe to say that the verdict will be favorable. For this is the shop of The Adams Company, Dubuque, Ia., specialists in the art of making good gears.

Each of the gears in the photograph has 86 teeth; is 22 in. in diameter and weighs 153 lb finish-machined. Each is intended for use in heavy-duty excavating equipment. Four gears are machined at one time in the hobber, though you may have to look sharply to detect all four.

The gears are made from Bethlehem circular blanks. These blanks are both forged and rolled by a unique single-step method that insures great strength, uniform density, and regular grain flow. Blanks made by this process can be furnished in a wide variety of sections, and in sizes ranging from 10 to 42 in. OD.

Excellent for heavy-duty gears, Bethlehem blanks also have many other end uses—sheave wheels, crane wheels, flywheels, turbine rotors, pipe flanges, etc. Whether you manufacture gears or something else requiring circular blanks, we'd like the chance to send you full details. A letter, wire, or telephone call will bring the complete story to you promptly.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

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Circle 553 on page 19

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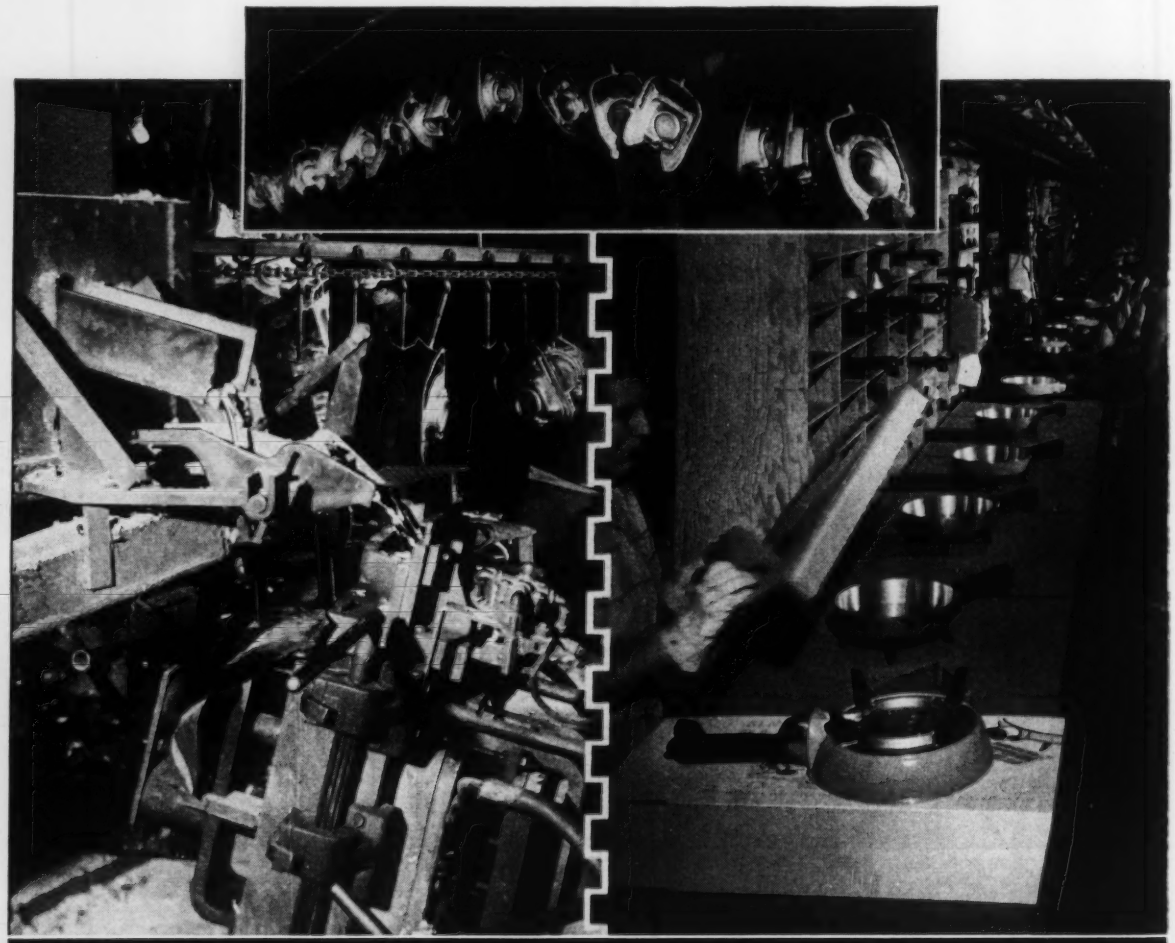

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Monarcast* methods provide highest quality metal structure, superior strength and dimensional accuracy. Flexibility of production operations is achieved, even during periods of product modification.

Monarch's unique finishing services featuring Velvaglaze* and Spectraglaze* give you "one source" responsibility from rough castings through finished components.

"Non-competitive" experience in both aluminum permanent mold and aluminum and certified zinc die castings offer you factual answers on the right methods to obtain highest quality at lowest product end-cost.

SINCE 1913
MONARCH
ALUMINUM
PIONEERS IN CASTING PROGRESS

* Velvaglaze, Spectraglaze and Monarcast are Trade Marks of

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MANUFACTURERS OF: *Aluminum Permanent Mold Castings • Zinc Die Castings • Aluminum Die Castings • Exclusive Velvaglaze Finishing • and Spectraglaze, colorful Porcelain Enamel on Aluminum Permanent Mold Castings.*

When you plan to purchase new motors, you'll want the best—at the most reasonable cost. You will demand built-for-the-job efficiency, and no compromises with quality. You will expect co-operation at each stage of design and development—and on through to manufacture and delivery on the date specified. And after installation, you'll want long-life and the minimum of down-time for servicing. At all times, you will appreciate being a special customer of the motor manufacturer—whether you buy one, or one hundred motors.

All this you can expect from Diehl. The best built-for-the-job motor at the most reasonable cost. You will get the benefit of 69 years of Diehl know-how applied to your particular requirements. For Diehl design, sales and installation engineers comprise one of the finest teams of electric motor experts in America today.

The emphasis at Diehl is on close liaison with all customers at every stage of production. Give your power problems to a Diehl motor specialist. Get the right answers and the best motors—fast. You invest in performance when you design with Diehl.

Diehl

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Electrical Division of THE SINGER MANUFACTURING COMPANY
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INTEGRAL AND FRACTIONAL HORSEPOWER MOTORS ARE AVAILABLE IN A WIDE RANGE OF TYPES AND SIZES

Circle 555 on page 19

Be sure the rotary stepping switches YOU use have this "free-floating" pawl

Automatic Electric Rotary Stepping Switches

insure bind-free operation

Look at the pawl in the small illustration above. Automatic Electric's Type 44 and 45 rotary stepping switches *can't* bind. Automatic Electric has eliminated the old-style pawl stop block that jammed the pawl and *caused* binding. Instead, Automatic Electric uses a unique "free-floating" pawl, and a set of stopping teeth on the end of the armature. These teeth engage the ratchet wheel smoothly, without jarring or jamming. They stop the wiper assembly positively, and position it exactly right on the bank contacts.

Automatic Electric offers many exclusive advantages over older type rotary stepping switches:

- Pawl breakage is eliminated
- Re-adjustment of armature stroke is never required
- There's no possibility of pawl binding, even at very low temperatures
- There's no possibility of double-stepping or overthrow

No wonder more and more design engineers are choosing Automatic Electric rotary stepping switches!

Plan now to use the Automatic Electric Type 44 or Type 45 rotary stepping switch in your products.

For complete information, write for Circular 1698. *Address* Automatic Electric Sales Corporation, 1033 West Van Buren Street (HAymarket 1-4300), Chicago 7, Ill. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

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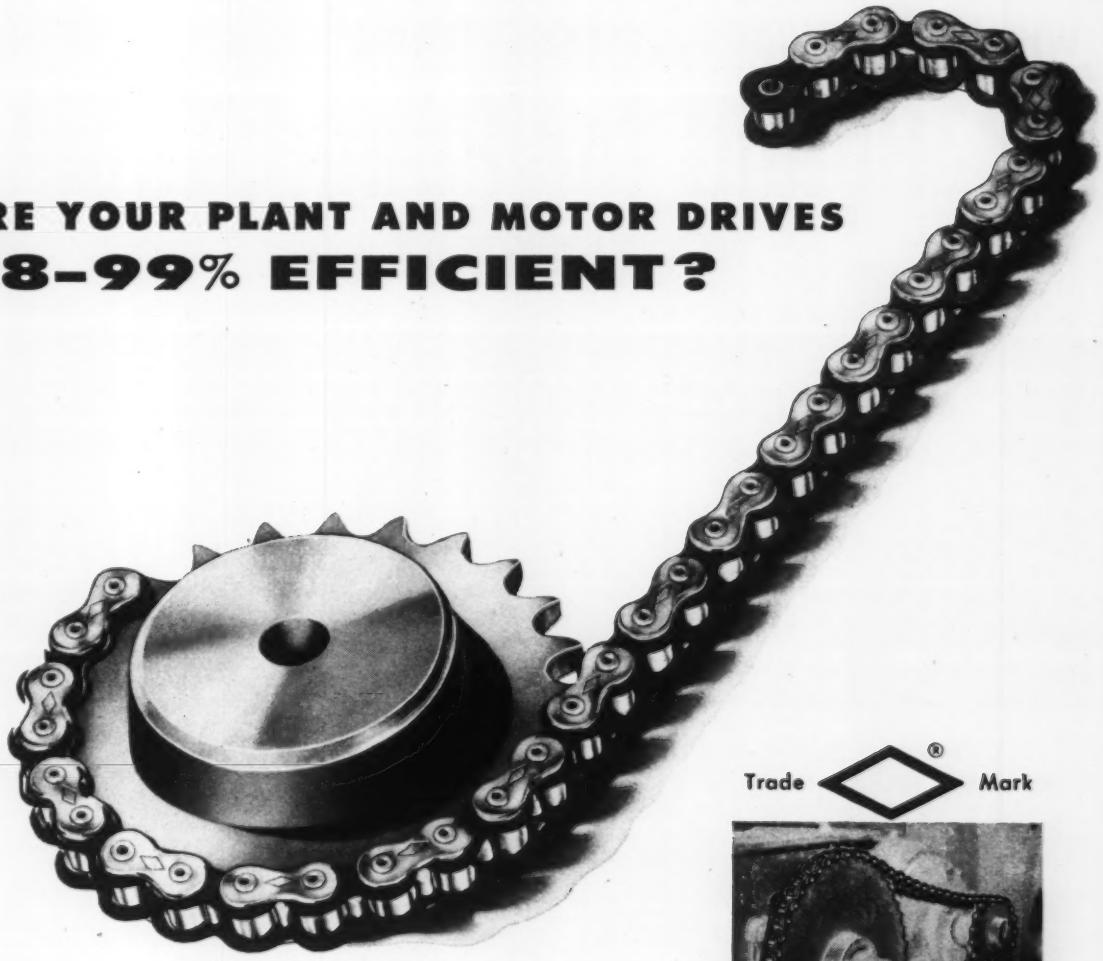
Originators of the dial telephone • Pioneers in automatic control

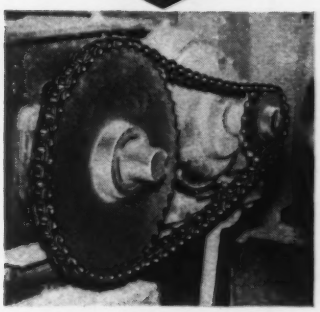
GENERAL TELEPHONE SYSTEM

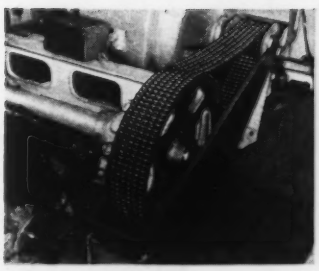
Circle 556 on page 19

ARE YOUR PLANT AND MOTOR DRIVES 98–99% EFFICIENT?



Trade ® Mark





YOUR DIAMOND DISTRIBUTOR WILL SHOW YOU HOW DIAMOND ROLLER CHAIN IMPROVES DRIVES

When planning new plant or motor drives or when replacing worn and less efficient drives, call your Diamond Chain Distributor. He will show you how uniform highest-quality Diamond Roller Chains improve drives, give longer maintenance-free performance, turn wasted power into useful work.

DIAMOND CHAIN COMPANY, Inc.
Where High Quality is Traditional
Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana
Offices and Distributors in all Principal Cities

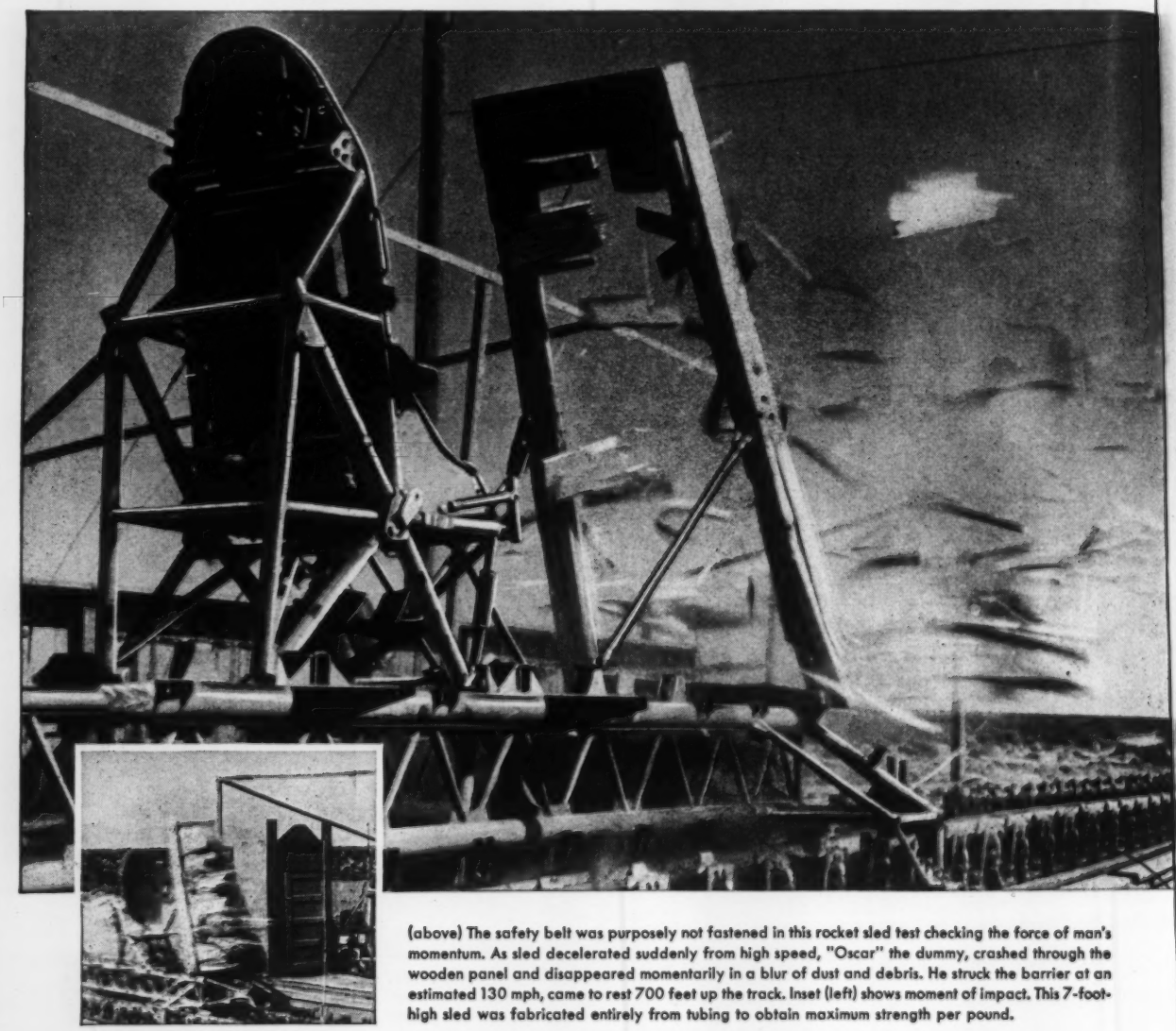
DIAMOND ROLLER CHAINS

Circle 557 on page 19

XUM

WHEN IT'S *MOVING* . . . MAKE IT TUBING

Pound for Pound, Tubular



(above) The safety belt was purposely not fastened in this rocket sled test checking the force of man's momentum. As sled decelerated suddenly from high speed, "Oscar" the dummy, crashed through the wooden panel and disappeared momentarily in a blur of dust and debris. He struck the barrier at an estimated 130 mph, came to rest 700 feet up the track. Inset (left) shows moment of impact. This 7-foot-high sled was fabricated entirely from tubing to obtain maximum strength per pound.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Construction is STRONGEST!

Where strength is an important requirement—such as this rocket sled application (left) for deceleration tests—manufacturers choose tubing for basic construction. They know that at any given weight, tubing is strongest of all mechanical shapes . . . as a beam... in torsion... under compressive loads.

And through many years of good experience, structural fabricators know that—dollar for dollar—Republic ELECTRUNITE® Steel Mechanical Tubing is their best buy. The original electric resistance welded tube, ELECTRUNITE is well-known for both quality and performance: It's available in a wide variety of sizes, gages, and shapes . . . in both carbon and stainless steel.

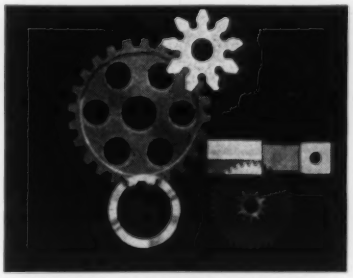
Predictable characteristics are assured because ELECTRUNITE tubing is made of Republic steel, to rigid Republic standards—each step carefully controlled from ore to finished product. Though produced in great volume, every length is consistently uniform, foot to foot, shipment to shipment. Wall thickness is uniform and so is concentricity. Surfaces are free from scratches and pit marks. It offers uniform response to heat treatment. It is easy to fabricate . . . often eliminates some costly fabricating or machining operation.

If you have a product that must be strong, safe and lightweight, investigate Republic ELECTRUNITE Steel Tubing. Republic's engineers can help you design it into your products or processes—economically and profitably.

Mail coupon below for all facts.

MORE REPUBLIC PRODUCTS MADE FOR MOVEMENT:

LIGHTWEIGHT ARMOR OF STAINLESS STEEL makes it possible for the Fruehauf Trailer Company's shiny new Volume Van to move a 35% bigger pay load. Stainless steel's exceptionally high strength-to-weight ratio permits the use of thinner, lighter sections—without loss of strength or sacrifice in safety. And where corrosion-resistance is important, stainless steel is ideal. We are glad to offer the services of our metallurgical and engineering departments. Contact nearest Republic office.



SMALL PARTS CAN OFTEN BE MADE FASTER, MORE UNIFORM—and at less cost using Republic Iron Powder. Complicated shapes, difficult to produce economically by conventional means, are easy to make by this new method. Republic metallurgists and engineers, with a thorough knowledge of all types of metals, can help you determine iron powder's suitability to your parts production. This service is available without cost or obligation. Just mail coupon.

THE PILOT OF THIS "EGG BEATER" IS SHIELDED from the power plant by a firewall, fabricated from .016 gage Republic Titanium, Type RS-70 Annealed. The extremely high strength-to-weight characteristics of this metal have made it possible to add range, speed and maneuverability to both military and commercial aircraft. Republic Titanium's very high resistance to corrosion also makes it useful for many non-military applications. If you have a strength-to-weight or corrosion problem, call your local Republic office. Send coupon for more facts.

STEEL

and Steel Products

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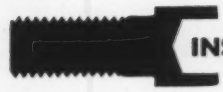
Dept. C-2365-A
3130 East 45th Street
Cleveland 27, Ohio

Please send me more information on:
☐ ELECTRUNITE Mechanical Tubing
☐ ENDURO® Stainless Steel Intended Use_____
☐ Iron Powder ☐ Titanium
☐ Have a Metallurgist call

Name_____Title_____
Company_____
Address_____
City_____Zone___State_____

Circle 558 on page 19



INSIDE INFO FROM HOLO-KROME

THE SECRET'S IN THE SOCKET!

Sharp hex socket corners mean less reaming —the payoff's on the production line with fewer damaged screws, less downtime and improved product appearance!

H- sharp socket ners resist reaming!

Compare These Other H-K Features!

COMPLETELY FORGED SOCKET HEAD . . . no drilling or broaching—metal fibers stay intact for stronger hex sockets.

SCIENTIFICALLY DESIGNED SOCKETS . . . depth carefully proportioned to give greatest head and socket strength, firmest key grip.

UNTAPERED WALLS . . . for better key fit, longer key and socket life, even tighter wrenching.

For the finest in Socket Screw products . . . for revolutionary SAME-DAY SERVICE, the name to remember is Holo-Krome!

LOOK INSIDE A HOLO-KROME SOCKET!

Send in the coupon below and we'll send you FREE an H-K Socket Cap Screw (we've omitted heat treating to let you get a better look at the mirror finish and sharp hex corners under the usual black finish). Look it over carefully, and see for yourself what a real difference H-K quality and skill can make!

Please send me FREE a Holo-Krome Socket Screw for my inspection.

NAME _____

POSITION _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

HOLO-KROME

THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN.

Sold only through authorized Holo-Krome distributors.

Circle 559 on page 19

NOW

a new STEAM valve with all the Rockwood Ball Valve advantages!

The new Rockwood Bronze Ball Valve for use with steam offers you many unusual benefits.

It Handles up to 125 Pounds of Steam per square inch and 350°F, with ease.

It's Leakproof — even after continued use Rockwood Steam Ball Valves stay dry.

It Opens and Closes Quickly — only a quarter turn is needed to open or close Rockwood Ball Valves.

It Has Longer Wear-Resistance — chrome-plated bronze ball withstands abrasion, scratching and pitting.

Rockwood's new Ball Valve for use with steam comes in pipe sizes from ⅜″ up to 2″. Send coupon for full information and data. Distributors in all principal industrial areas.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
1225 Harlow Street
Worcester 5, Mass.

Send me illustrated folder on Rockwood's new Ball Valve for use with steam.

Name.....

Title.....

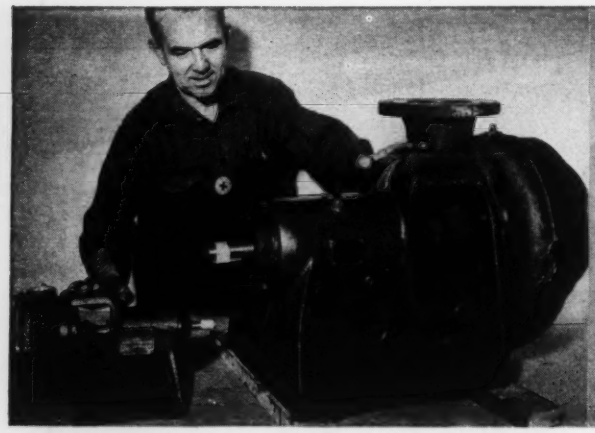
Company.....

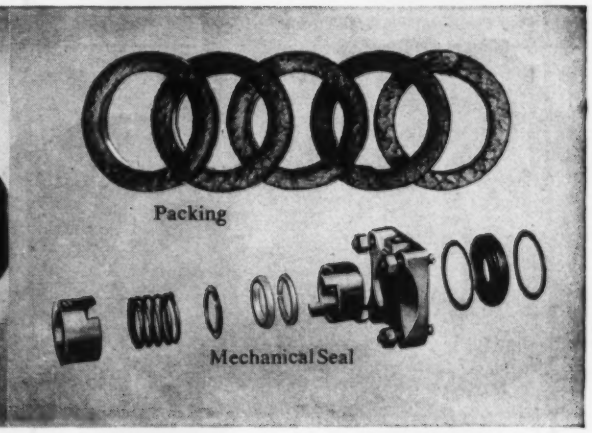
City.....Zone..State.....

Circle 560 on page 19

WHAT'S YOUR P.Q.?*

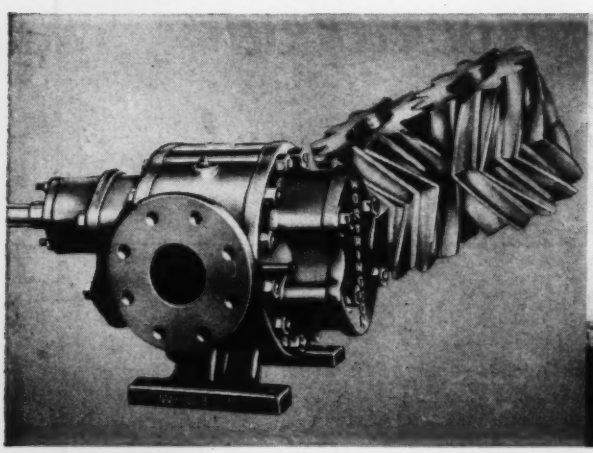
*PUMP QUOTIENT

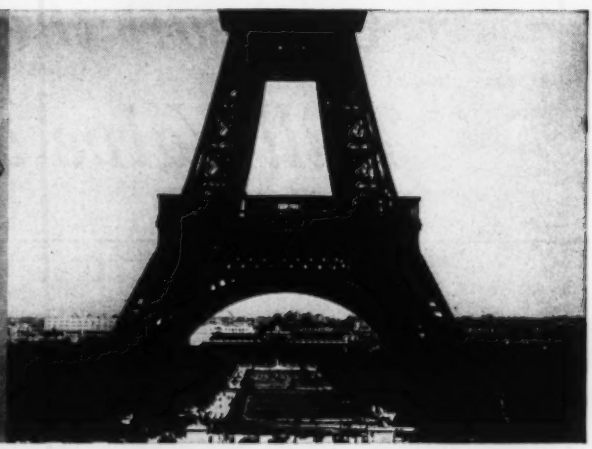




Pump standardization—how do you benefit? By standardizing, you can often drastically cut your spare parts inventory. With Worthington's SESC (Standard End Suction Centrifugal) line, you are also assured of immediate delivery from factory or distributor stocks. Because the SESC line consists of standardized "parts" not "pumps," it can be built in many different combinations . . . 70,480 to be exact. For all these reasons, more and more companies are turning to SESC pumps. See bulletin W-300-B4.

Packed stuffing box or mechanical seal—which is preferred? Each has its applications. Mechanical seals are gaining in popularity year after year. With Worthington's Standard End Suction Centrifugal pumps you not only get your choice of mechanical seals—or packing—but you can easily convert from one to the other using standard stock parts. This "interchangeability" is just one of the many extra advantages of Worthington's SESC line. For more details write for bulletins W-300-B4 and W-350-B16.





Which pump is best for difficult suction conditions? Worthington's close-clearance rotary pump is self-priming and can operate under vacuums as high as 28 inches of mercury. The large unobstructed suction opening in this herringbone gear pump permits operation with thin or viscous liquids at high efficiency. The double-helical gears balance all end thrust, eliminate trapping of liquid between gear teeth and provide a quiet, pulsation-free flow at high speeds. For the full story, ask for bulletin W-483-B2.

Whose pumps would you expect to find in the Eiffel Tower? If you said "Worthington's," your P.Q. is all right. The original steam-driven pumps that power the Eiffel Tower's 100-passenger hydraulic elevators were built by Worthington back in 1889. The most recent additions, modern electric-drive Worthington pumps, moved into the Tower just last year. Today as then, wherever men must move liquid, they turn to the company with a reputation for performance. Worthington Corp., Harrison, N. J. PC. 6.5

WORTHINGTON

Basic Idea:

SOLVES MANY REDUCER MOUNTING PROBLEMS

FOOTE BROS. NEW

Line-O-Motor Drive

One base supports both speed reducer and motor in this simple, practical and foolproof mounting system . . . Now you can use standard N.E.M.A. motors and make change-overs in minutes—reducing both costly down-time and motor inventory.

Line-O-Power motorized drive solves many old problems . . . and opens new fields of advanced design for new applications. Available 1-75 H.P. for all Service Classes—Horizontal, Vertical, and Vertical Extended with Foot or Flange mounting—Double or Triple Reduction units available in Ratios from 5.06:1 to 238:1.

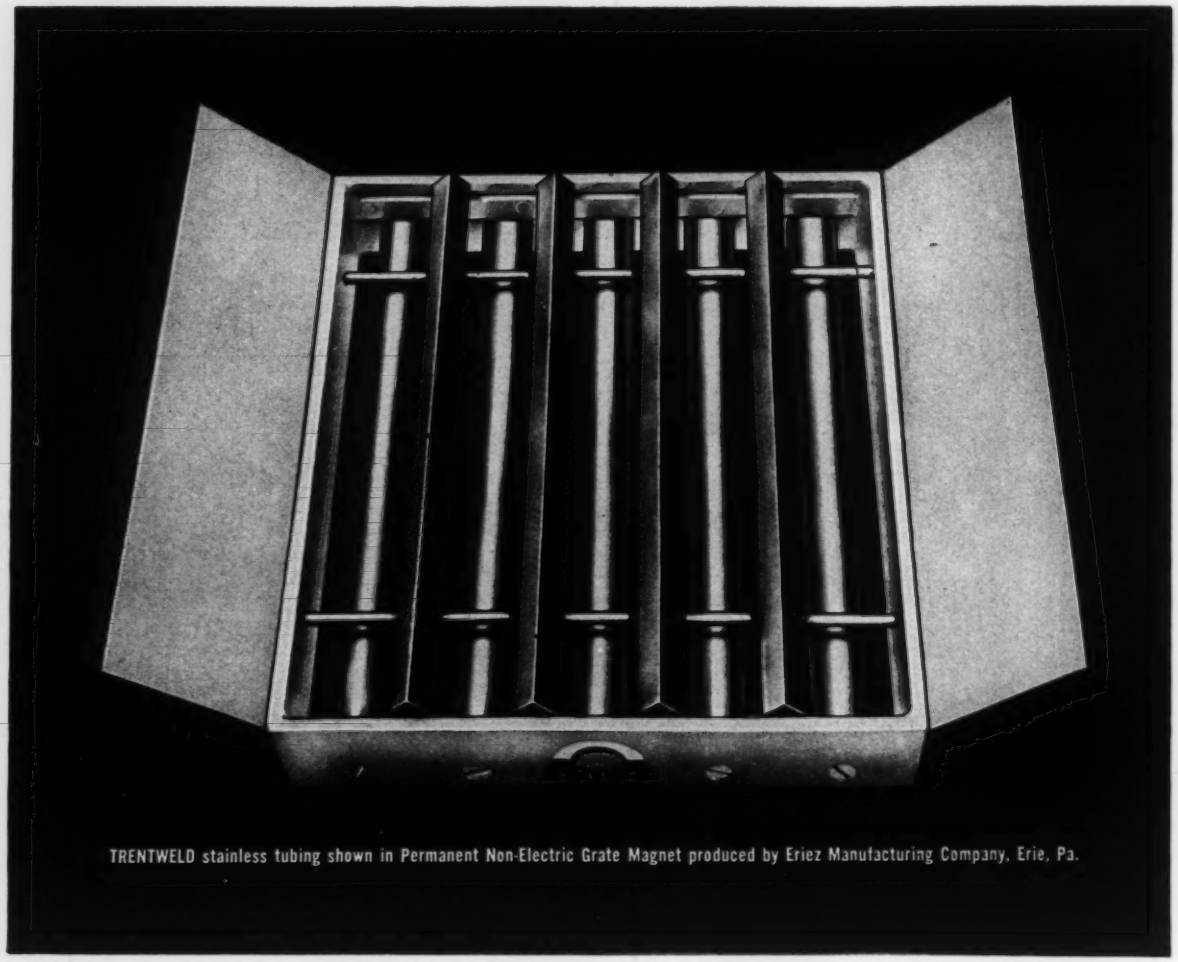
FOOTE BROS.

Better Power Transmission Through Better Gears

4543 S. WESTERN BLVD., CHICAGO 9, ILLINOIS

Department O

Write for your Line-O-Motor Catalog today



TRENTWELD stainless tubing shown in Permanent Non-Electric Grate Magnet produced by Eriez Manufacturing Company, Erie, Pa.

how TRENTWELD stainless tubing traps "tramp iron" in product flow...

As free-flowing products such as chemicals, grains, sugar or spices flow through this separator unit, large and small iron contamination is seized by powerful magnets and held firmly to the five stainless steel tubes.

This is a unit that's normally given long, hard use. That's why TRENTWELD stainless steel tubing is chosen to house the Alnico V magnetic elements. For stainless resists abrasion and corrosion . . . its smooth surface offers a minimum of resistance to product flow . . . and stainless is strong—lasts indefinitely. What's more, stainless is the easiest of metals to keep clean and sanitary.

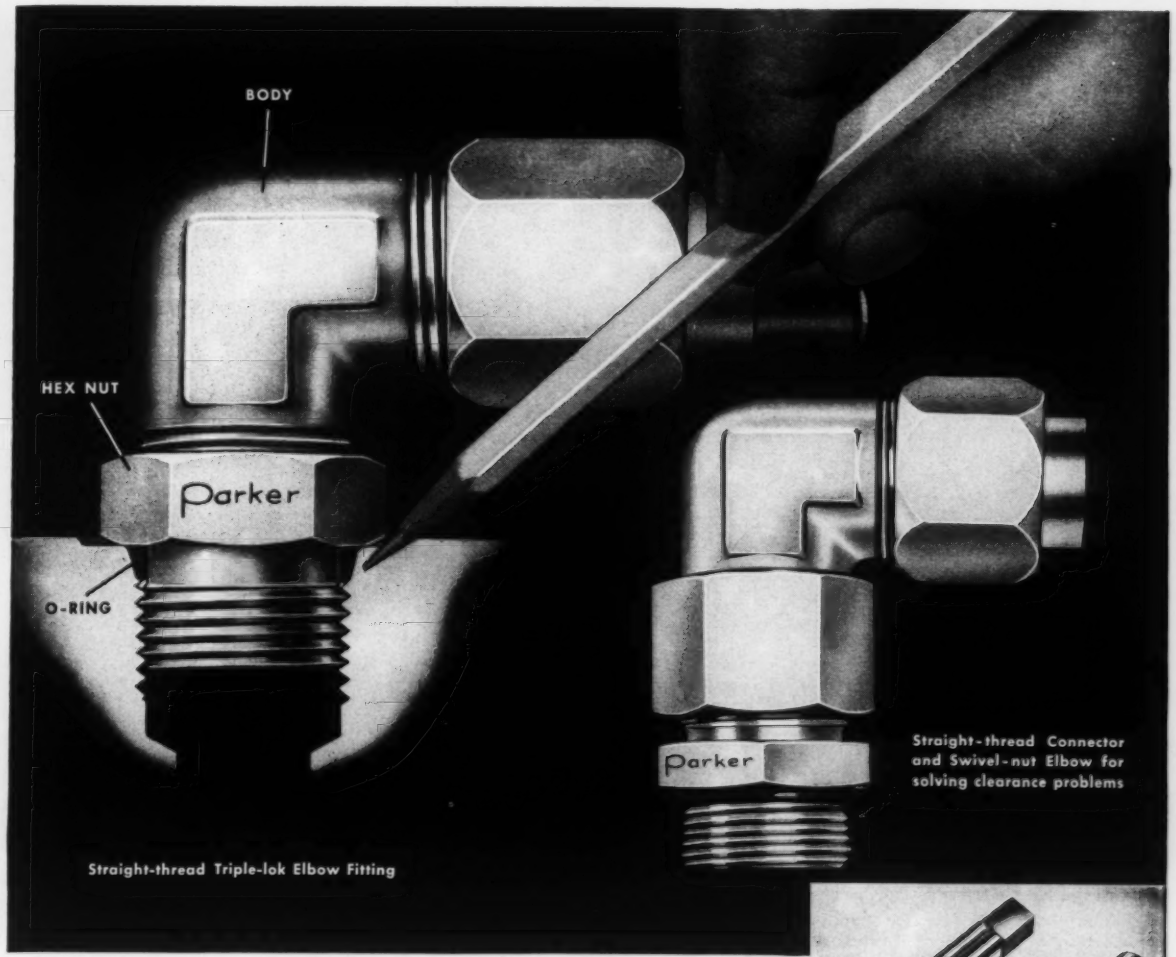
And equally important to you is the fact that TRENTWELD is made by *tube mill specialists* —by the new, patented *Contour-Weld* Process. That means stainless pipe or tubing with a smoother I.D., free from any weld bead or undercut.

So when you need stainless or high-alloy pipe or tubing, make sure it's TRENTWELD. You can't buy better!

TRENTWELD

STAINLESS STEEL TUBING

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)



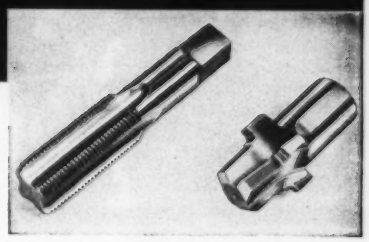
New Parker *straight*-thread fittings solve your leakage problems

Now you can forget about high-pressure hydraulic problems resulting from tapered pipe threads. Forget about leakage . . . about the danger of cracking or distorting valve bodies by over-tightening the fittings . . . about damaged threads from over-tightening to obtain proper positioning. Forget about messy pipe "dope".

You can eliminate all of these problems by using new Parker *straight*-thread fittings with positive O-ring seals. (See illustration above.)

Parker *straight*-thread fittings are now being supplied in response to the growing demand for this new type of leakproof, trouble-free connection. They are shorter and have smaller hexes than the AN fitting for the old AND 10050 boss. *Straight* threads are available on *Triple-lok* (the industrial standard flare tube fitting) and on *Ferulok* (flareless fitting for heavy steel tubing).

This is another example of Parker's pioneering leadership in the field of hydraulic fittings. Mail the coupon today for complete information.



Precision thread-tapping and counterboring tools for making accurate *straight*-thread boss (to receive these new Parker *straight*-thread fittings) are now available with machining drawings from Parker.

TUBE AND HOSE FITTINGS DIVISION
Section 412-N

The Parker Appliance Company
17325 Euclid Avenue
Cleveland 12, Ohio

Send Catalog 4301.

Name_____

Company_____

Address_____

City_____ State_____

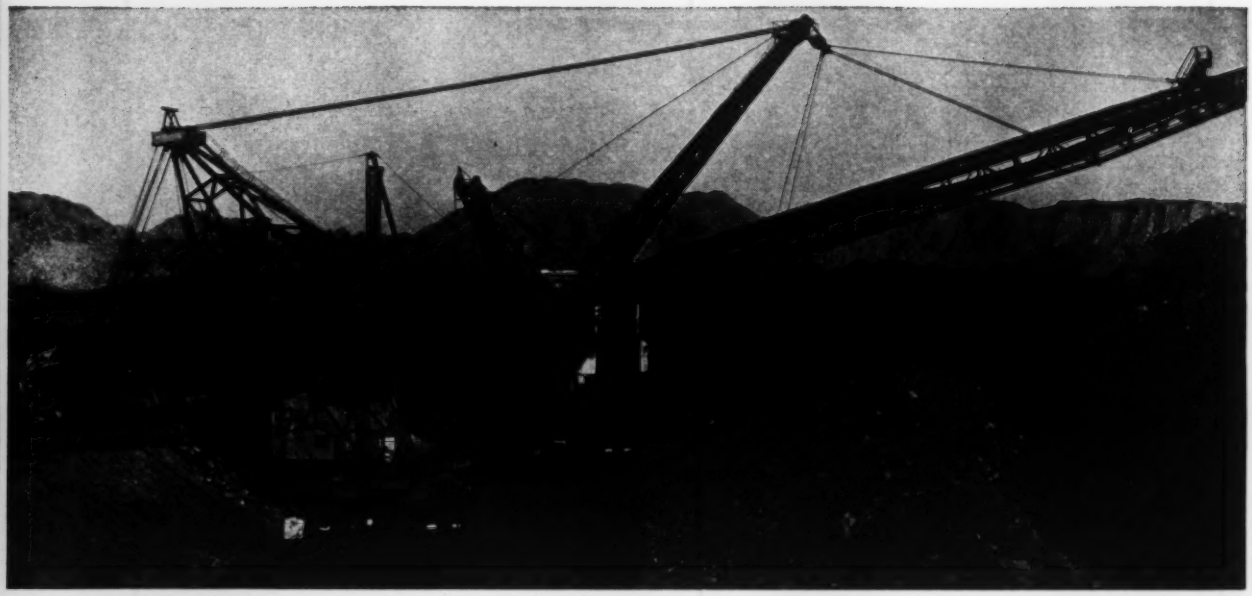
Parker

Hydraulic and fluid system components

Circle 564 on page 19

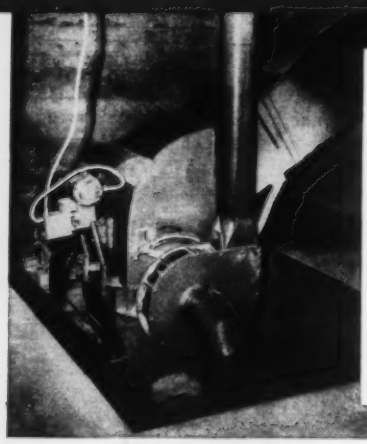
XUM

HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS...



Lower-Cost Dirt

This mammoth coal stripping machine scoops out 2000 yds. of overburden an hour, cuts the cost of stripping coal that lies under 50 to 80 ft. of overburden. Its 22-ft. wheel carries eight buckets, each 4 ft. wide, with lips of 2½-inch USS "T-1" Steel. USS "T-1" Steel has the strength and toughness to scrape through shale, rock, mud, and ram into ton-and-a-half boulders day in and day out. In addition, it is weldable in the field, costs less than other steels that could be used—and outlasts them. This wheel excavator was designed by United Electric Coal Companies, Chicago, for their own use.

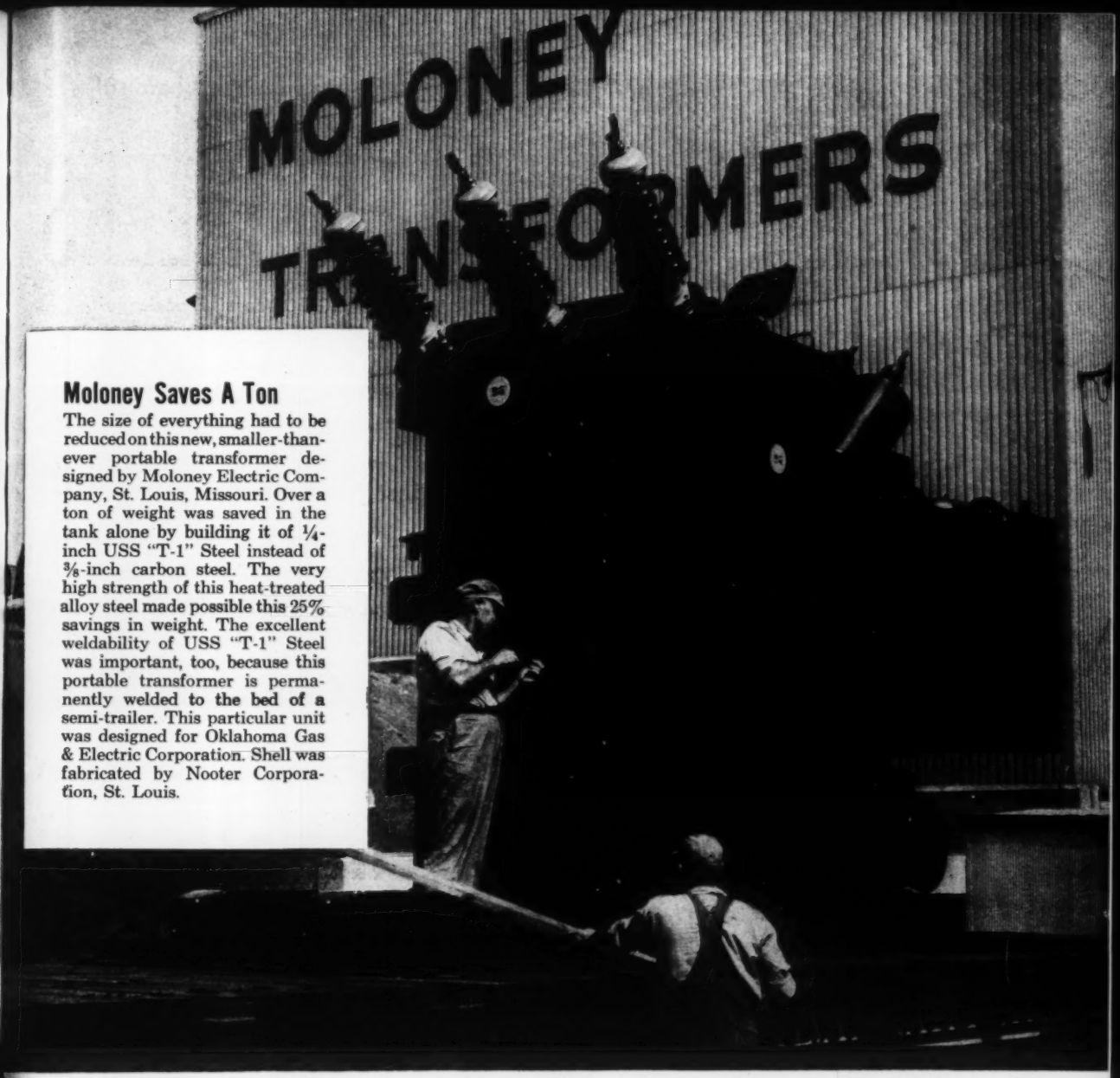


Shucks, hay fodder, corn cobs, and grains are extremely abrasive when sucked out of a hammermill at high speed. And the blades of the fan that does the sucking must withstand the abrasion and be weldable. Myers-Sherman Company, Streator, Illinois, manufacturers of industrial hammermills, switched to USS "T-1" Steel and saved $7 on fabrication of each fan.

Heavier Loads, More Production

Mack Welding Company, Duluth, Minnesota, has used "T-1" Steel to increase the durability and at the same time reduce the weight of its Orange Peel Type, Four Tine Pulpwood Grapples. With these new, lightweight grapples, crane operators can handle increased payloads with present cranes. As a result, production can be increased as much as 40 percent.

Circle 565 on page 19



Moloney Saves A Ton

The size of everything had to be reduced on this new, smaller-than-ever portable transformer designed by Moloney Electric Company, St. Louis, Missouri. Over a ton of weight was saved in the tank alone by building it of ¼-inch USS "T-1" Steel instead of ⅜-inch carbon steel. The very high strength of this heat-treated alloy steel made possible this 25% savings in weight. The excellent weldability of USS "T-1" Steel was important, too, because this portable transformer is permanently welded to the bed of a semi-trailer. This particular unit was designed for Oklahoma Gas & Electric Corporation. Shell was fabricated by Nooter Corporation, St. Louis.

HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,000 psi and its minimum tensile strength of 105,000 psi, can help you design or build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking severe impact and abuse at sub-zero temperatures. Its excellent weldability can help you cut the cost of fabricating high strength parts, and reduce repair and maintenance expense. Its good creep rupture strength can help you put more durability in equipment that operates at temperatures as high as 900 degrees F.

Somewhere in your operation, versatile USS "T-1" Steel can help you. Write, wire, or phone United States Steel, Room 5393, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

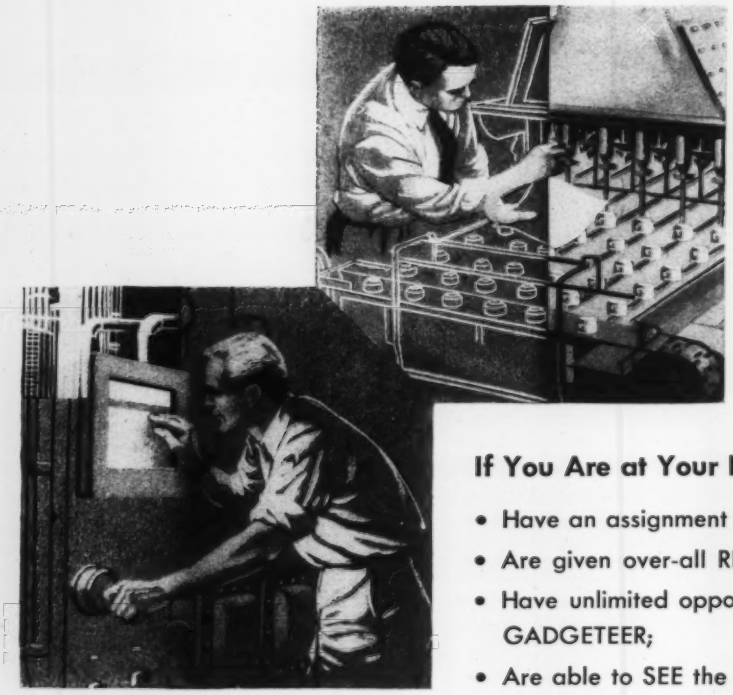
USS "T" CONSTRUCTIONAL ALLOY STEEL

USS

SEE The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL

XUM



Mechanical, Chemical Electrical

ENGINEERS

(0-10 Years' Experience)

For development of

- Automatic Machinery
- Process Equipment
- Instrumentation • Controls

If You Are at Your Best When You . . .

- Have an assignment that YOU can completely encompass;
- Are given over-all RESPONSIBILITY for a development;
- Have unlimited opportunity to CREATE, INVENT, GADGETEER;
- Are able to SEE the results of your efforts, then . . .

Look to the Future in Research and Development with

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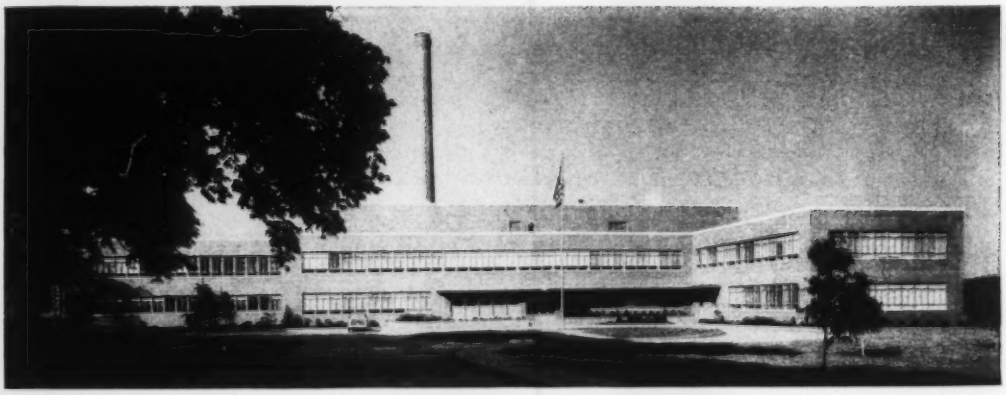

- Advancement in professional and management fields.
- National recognition for excellence of executive development program.
- New Research and Development Center located 15 miles outside Cincinnati.
- Pleasant surroundings of suburban living.

For further information about the interesting opportunities in Procter & Gamble's new Engineering Development Division, write today to:

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Engineering Development Division
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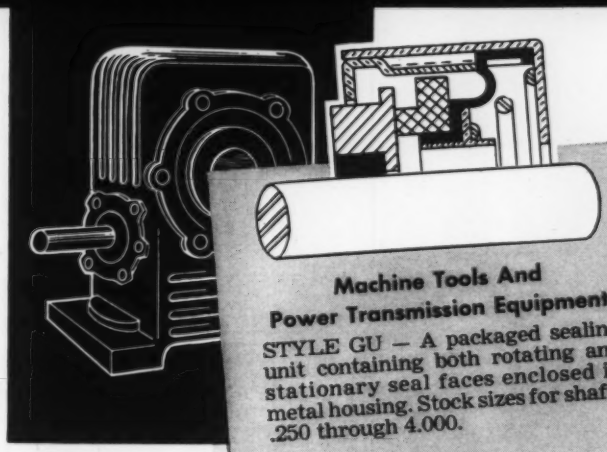
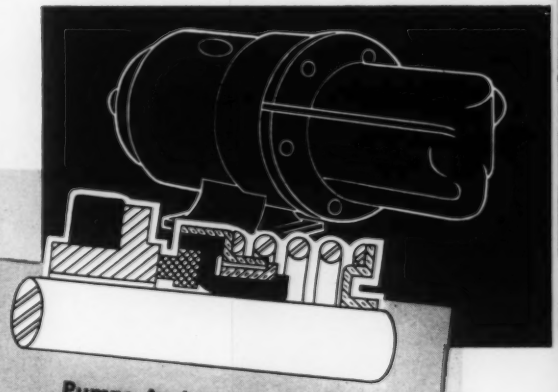
Mt. Healthy Station, P. O. Box 175
Cincinnati 31, Ohio

Circle 566 on page 19



Machine Tools And Power Transmission Equipment

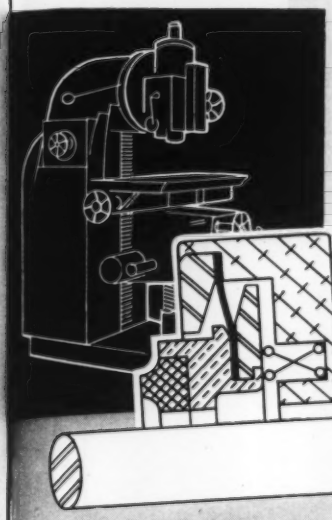
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

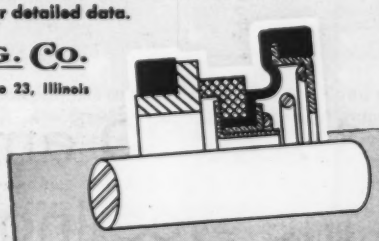
A Complete Line
GITS SHAFT SEALS
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

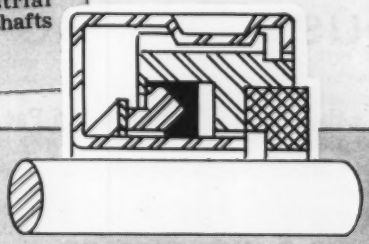
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



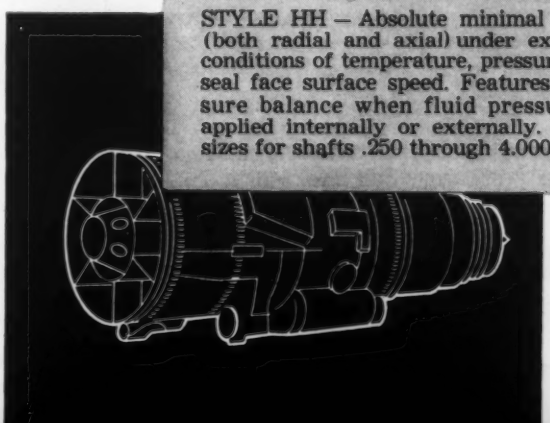
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



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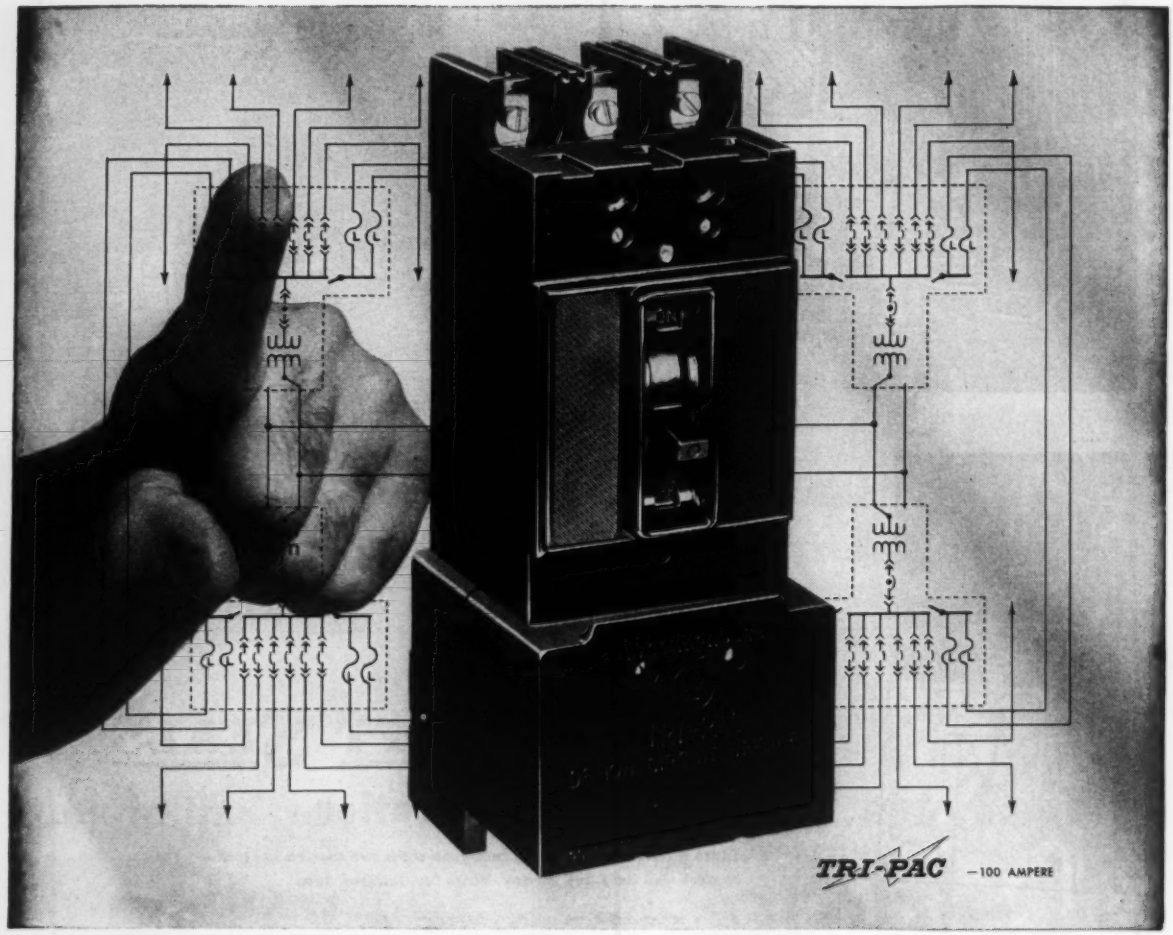

100,000 amps gets a new boss—the Westinghouse Tri-Pac breaker

The new Westinghouse Tri-Pac breaker is the smallest protective device for electrical circuits where 100,000 amps can be poured into faults. It is the most practical and economical solution to the constantly increasing interrupting requirements of network systems and those fed by large transformers.

Co-ordinated triple circuit protection—thermal, magnetic, and current limiting—combines the inherent advantages of both the molded case breaker and fusible current limiters. The breaker trip portion of the Tri-Pac handles overloads and moderate faults, eliminating fuse replacement. On higher currents, the current limiters in Tri-Pac trip before the breaker portion, insuring the prompt protection required at high currents.

Tri-Pac costs much, much less than large air current breakers of equivalent rating and provides more safety and convenience than switches combined with fusible elements. New Tri-Pac breakers insure positive protection against all system current faults—large or small—at a new and greater economy.

A Westinghouse sales engineer can show you additional reasons why the new Tri-Pac breaker is your best buy for powerful circuit system protection. Call him, today. J-30216

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Circle 568 on page 19

Use WELDED STEEL for Greater Strength with Less Weight!

Gas Turbine Components are also produced in welded steel. The turbine cylinder housing for a Westinghouse Industrial Gas Turbine, shown above, and the parts and assemblies illustrated at the left, will give you a comprehensive picture of Mahon capabilities and facilities . . . assets which enable the Mahon Company to produce virtually any heavy part or assembly in welded steel at lower cost. This is particularly true in short run production programs where the manifold advantages and economies of weldments are most fully realized. If you require parts or assemblies for processing machinery, machine tools, or any other type of heavy mechanical equipment, you can call on Mahon with complete confidence. You will find in the Mahon organization a unique source for welded steel in any form . . . a source with long experience and complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

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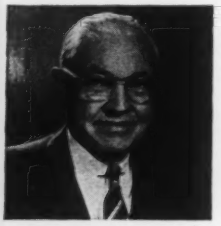


Technical-ities

By John S. Davey

Coarse Threads Better Than Fine For Many Jobs

The load and stress concentrations on threads are lower in standard coarse thread fasteners than in fine threaded ones. Flank engagement is also greater because coarse threads are deeper. Except in such cases where fine adjustments are needed, coarse threads are, therefore, preferable to fine threads. They have greater resistance to stripping and, consequently, can be more highly torqued to make a stronger assembly.

PRODUCTION SAVINGS

Coarse thread fasteners tighten with only two-thirds the revolutions needed for fine threads. So your assembly time is faster, too. Coarse thread bolts enter nuts or mating holes with less tendency to cross thread when not truly positioned. In hard-to-reach areas, this ease of starting can often be your deciding factor. Bear in mind, too, that coarse threads need less "babying" in handling since they're less apt to be damaged.

All in all, coarse threaded standard fasteners prove best for an assembly because of their additional clamping strength—and best for the assembler because of their extra economy and production advantages.

Spin-Lock screws increase holding power by 20%

EXPERIENCE confirms that Spin-Lock screws hold tight under conditions of vibration or repeated heating and cooling. Their strong teeth have a ratchet action on the bearing surface—the acute angle lets the screw tighten fast and easily, until the teeth actually embed into the seat upon tightening, as shown in the sectional photomacrograph below. The almost vertical face of the teeth then resists counter-rotation and loosening. As a result, it takes about 20% more torque to loosen a Spin-Lock than to tighten it.

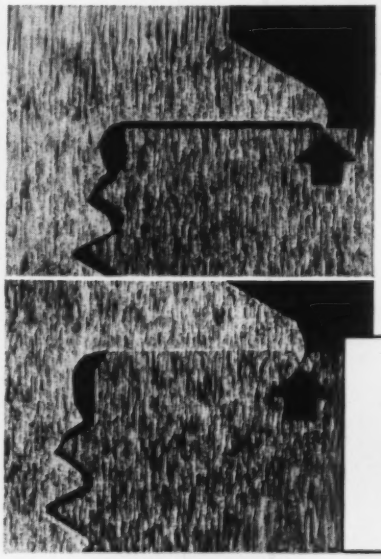
LOWER COST ASSEMBLY

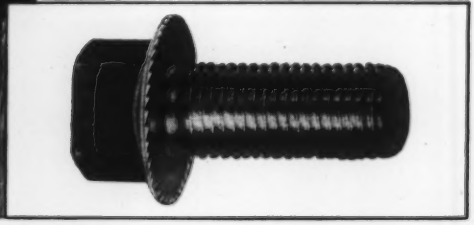
Spin-Lock screws avoid need for washers or external locking devices. One-piece construction, they allow faster assembly and can be easily handled and driven in cramped spaces.

STRONGER ASSEMBLY

Heat treatment gives the teeth hardness and toughness. Spin-Lock screws can, therefore, be reused when removed with but slight loss in holding power. The extra strength also permits tighter fastening for a stronger assembly without risk of stripping threads.

Screws with hex, pan, truss and flat heads are available. See Sweet's Product Designers file or write Russell, Burdsall & Ward Bolt and Nut Company. Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.





High strength bolts improved product at a saving

A mechanical vibrating shaker naturally suffers severe abuse itself from vibration. One manufacturer of such machines used costly special fasteners and lock nuts to control tendency of the product to loosen up.

Asked about it, RB&W recommended a standard high strength bolt, heavy nut, and two hardened washers. These permitted a high tensile clamping force to be developed. Residual tension was ample for the most severe operating conditions and kept the bolts tight. Result: A 25% saving in annual fastener cost, the constant availability of standard items, and less maintenance for the product. You too can draw on RB&W experience for technical help to assure a strong assembly and to cut costs.

Circle 570 on page 19

Miller

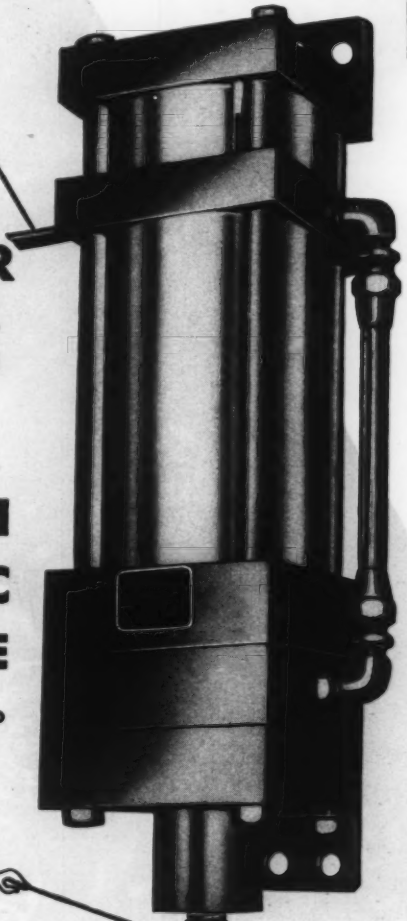
FLUID PRESSURE BOOSTERS

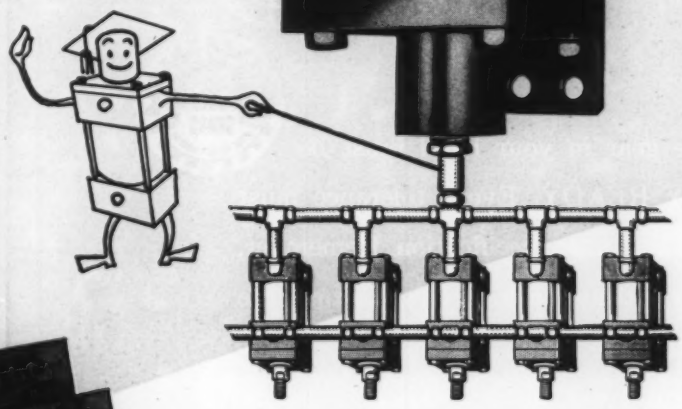
BOOST 80 PSI AIR

Input Range: 40 to 3000 psi Air or Fluid

TO 2000 PSI HYDRAULIC PRESSURE

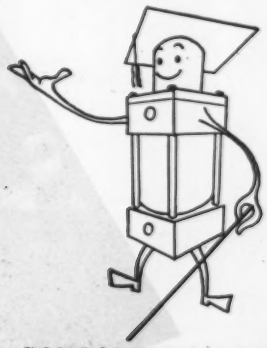
Output Range: 200 to 10,000 psi Fluid





- Save space, weight and investment cost by replacing pump installations in many applications
- Less costly to install, operate and maintain
- **Hold pressure indefinitely** without the motion and heat generation of ordinary pump circuits
- Provide — at point of cylinder thrust — more efficient power with less weight in less space than direct driven air cylinders
- Save up to 95% of air consumed by direct driven air cylinders
- Operate at speeds of 30 to 450 strokes per minute

NOTE: In addition to its most complete line of "Custom-Built" Boosters available on normal delivery, Miller offers 5" bore 25 to 1 ratio boosters for immediate delivery in either 6" or 12" stroke. Write for data and prices.



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Circle 571 on page 19

XUM

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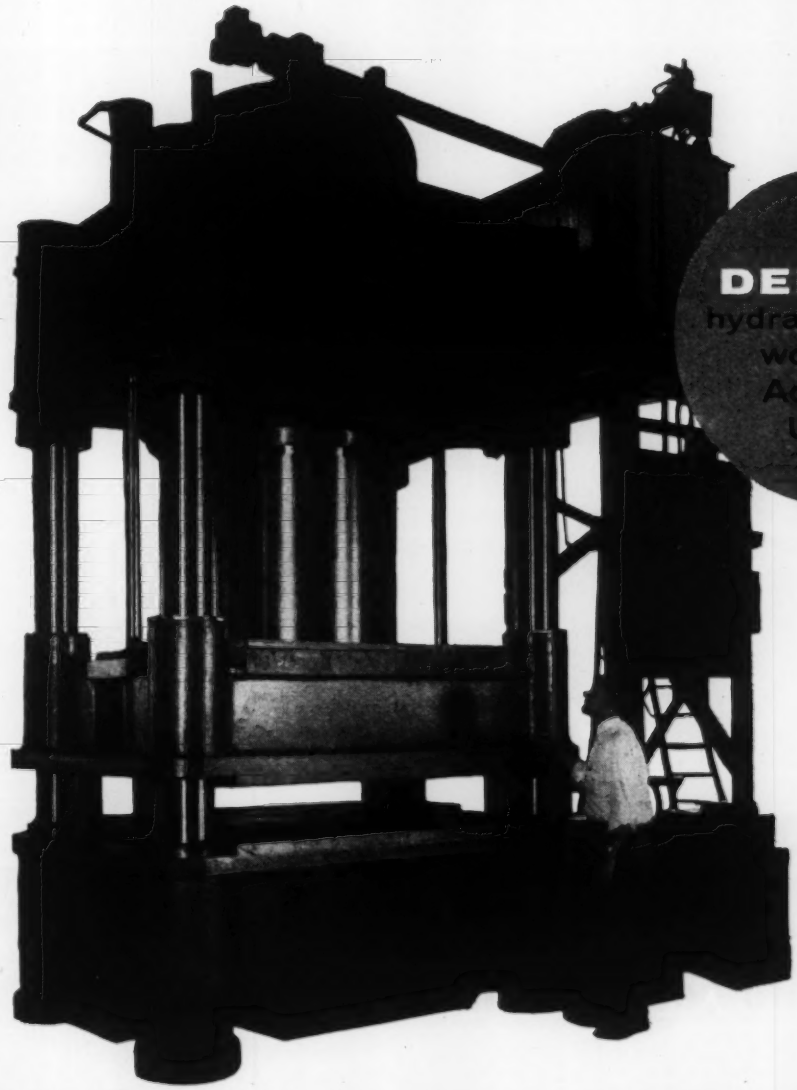


How **DENISON** hydraulic power works for Adamson United

Precision control for a metal monster

Denison variable volume axial piston type pump with pressure compensating control, key to this hydraulic system for Adamson United Press.

● To Denison Engineering went the task of designing accurate, foolproof control equipment for this huge compacting press built by Adamson United, Akron, Ohio. Covering more than 40 square feet of platen area, the press has a 40-inch ram designed to operate on a 2300 psi hydraulic system.

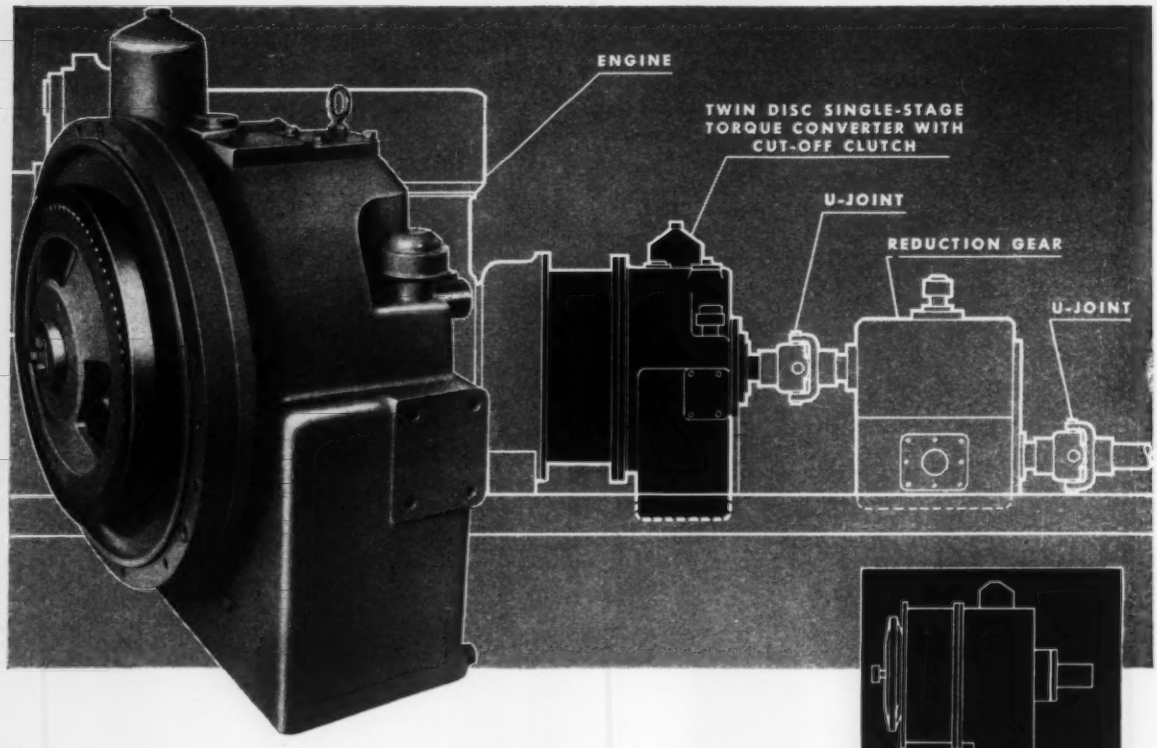
The control system developed by Denison employs a variable-volume axial-piston pump driven by a 15 h.p. motor. A manifold-type hydraulic panel completes the system.

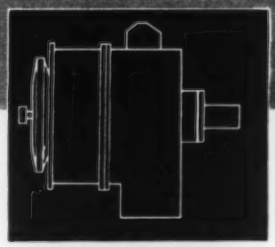
Engineering consulting service like this is available to you at all times to save your design time and assure dependable, efficient performance of your hydraulic circuits. Write us. Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

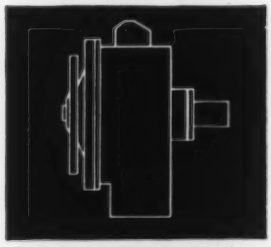
DENISON Hydr OIL ics

Circle 573 on page 19

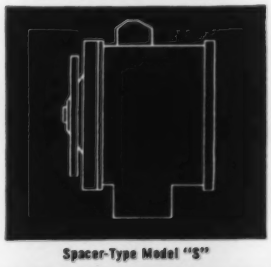




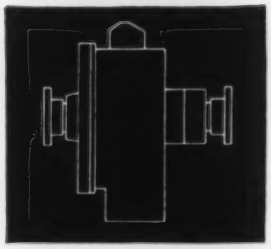
Model "C," with clutch input



Model "S," with spider drive input



Spacer-Type Model "S"



Model "U," with flange input-output

Design this new *SINGLE-STAGE* Torque Converter into your machine

If your problem is matching single-stage torque converter characteristics to powered equipment, here's the ideal solution: Design the new Twin Disc Single-Stage Torque Converter into your machine!

This new single-stage unit is designed and built with all the latest engineering advances—yet retains the basic features that have made Twin Disc Torque Converters the world's most widely used for industrial applications. It's now available in the 1500 Series . . . in a variety of model arrangements . . . in a number of torque capacities . . . from 30 to 207 hp input . . . to meet the widest variety of requirements. Its unique but field-proven design eliminates the need for a free-wheeling device . . . eliminates one more possible trouble spot. Its heavy-duty construction features ample bearing surface throughout . . . for long life and minimum maintenance . . . even where the going is roughest.

Find out more about this new single-stage torque converter . . . how it can help bring out maximum performance in *your* powered products. Write Twin Disc Clutch Company, Hydraulic Division, Rockford, Illinois. Request Bulletin 508.

A *complete line* of torque converters, both single-stage and three-stage, for internal combustion engines from 30 to 1000 hp.

TWIN DISC

TWIN DISC
Torque Converters

Circle 574 on page 19

MACHINE DESIGN
October 18, 1956

The S Factor

ONE crop at least shows no signs of a production surplus—engineering graduates. Supply and demand laws seem to be operating and reports show a substantial rise in prices for this year's crop.

Are current starting salaries realistic or is the market inflated? Can a graduate from a four-year course with no industrial experience possibly be worth $5000 a year—more if he's in the top quarter of his class?

A man's value to his company, according to Dan McQuaid, can be computed by the formula $V = A - S$, where A represents his ability and S is the amount of supervision he needs to bring out that ability.

Obviously, when a man first reports to work the S term is so large that V is almost zero. So S is actually a function of time and should diminish rapidly as time goes on. How rapidly depends on two factors: the quality of supervision provided by the employer and the man's own willingness to accept responsibility and to fit into the organization as a reliable operator.

Therein lies the key to the question in the second paragraph. Responsibility for making the answer become "yes" rests equally on management and on the young engineer.

Well planned orientation and on-the-job training programs, as outlined in Chet Linsky's article beginning overleaf, are management's contribution. Their purpose is to reduce the period of internship that bridges the gap between the completion of academic education and the performance of responsible professional work.

Initiative properly comes from management. But responsibility for closing the gap is shared by the young engineer himself. Only when he has succeeded in reducing his S factor to a nominal quantity can he be considered to be well on his way toward full professional status.

Colin Carmichael

EDITOR

XUM

Indoctrinating newly hired technical personnel in company policies and practices is a recurrent problem. Here's a three-stage program designed to speed the process of

By Chester Linsky
Assistant Professor of Industrial Engineering
The Pennsylvania State University
University Park, Pa.

Training Design

SKILLS of the experienced engineer or designer —compounded equally of talent, resourcefulness and technical knowledge—are neither imparted nor absorbed overnight. The premium set on these qualities explains, at least in part, the current situation where the demand for such experienced personnel exceeds the supply. And, furthermore, because enough college graduates are not entering the field today, the necessary pools of future design management personnel are not being established.

Solution of the problem reaches further than merely increased recruiting activity. Holding on to, developing and advancing young engineers now at work is perhaps of greater importance.

Because the engineering activity—and particularly design—is so highly specialized, it is difficult to teach the essential skills on the college campus. Instead, development of the design engineer is best accomplished through the means of a well-designed on-the-job program that emphasizes the interrelation between product and the manufacturing process. Lending direction to such a program is the everyday search for new and better ways to sharpen up designs, cut material costs and reduce manufacturing complexity.

Organizing a training program may not, at first thought, appear to be much of a problem. There is, it is soon discovered, no pat solution. In a single plant, engineers are at work not only in product design, but in equipment and process design, research, and development.

The desired solution would perhaps be to tailor a training program to satisfy the individual needs of each type of engineering activity. Obviously, where an organization has several different design activities going on, a program of this nature would be more ambitious than practical. The compromise solution is probably one where the young designers follow a common program during the earlier stages of their training, gradually shifting over at a later stage to training more specifically attuned to their individual needs.

A three-stage program similar to that shown on the facing page may fulfill these requirements. Successive stages of the program, while introducing progressively more complex activities of the plant, add to the trainee's background of technical knowledge. Wherever possible, training emphasizes the design situations that he is likely to encounter later on. Although the mechanics of training will differ from company to company, skeleton of the three-stage program might follow the suggested checklist.

There is nothing particularly unique about this approach; its essential features are incorporated in most plant training programs. Note that, while no specific mention is made of the exact makeup or contents of each stage, all the essentials are there to help the young engineer go through his basic plant training, acquire the tools and techniques of his profession, be integrated into the organization, graduate to responsible assignments, and gain professional recognition.

There are too many variations in corporate structure, plant facilities, organizational strength, time limitations, and job assignments to permit detailing of programs and methods which could be effectively standardized. The exact method of implementing and programming design training should be worked out on the local level.

Failure to do this, incidentally, is the reason why many plant training programs fall short of management's goal. Someone decides that because Company *X* is operating a certain type training program with all the earmarks of success, it would be desirable to use it as the basis for developing his own program. This approach is about as ridiculous as the suggestion that, because Company *X* does a nice job of design, we should pattern our own design department, its functions and tech-

Engineers

TRAINING CHECKLIST

Stage I

1. Plant orientation
2. Company policies
3. Company products
4. Company processes
5. Technical coursework

Stage II

1. Department activities
2. Company and department standards
3. On the job training
4. Technical societies activities
5. Advanced technical coursework

Stage III

1. Project supervision
2. Applied research
3. Special schools
4. Management preparation
5. Company and customer liaison

niques after it. Common sense indicates that this would invite trouble. Personalities and problems vary so greatly from company to company that a procedure that works well with one may fail completely with another.

Discussion in this article is limited to establishment of the broad needs of a designer's training program; specific details unique to an individual organization are left in the hands of the organization itself.

The First Stage

It will be assumed that a purpose of any program is to impart not only technical knowledge, but also a certain degree of organizational or corporate consciousness. Laying out this phase of the program requires answers to certain basic questions.

1. What aspects of company policy are important to the engineer?
2. To what degree do such policies affect the technical and corporate acceptability of his work?
3. In what detail should organizational structure be presented?
4. What training methods will most firmly establish organizational consciousness as a fundamental attribute in the designer's makeup?

Going back to the basic program, its intent becomes quite apparent. In the first stage, the problem of orienting the college graduate and familiarizing him with the plant, its products, policies and operations is treated. The production phase is one of the most important in the designer's training process.

Through knowledge of shop operations, fabricating equipment and general production problems, the trainee's seasoning process begins. Because designs are ordinarily governed by practical limitations associated with the shop's ability to produce, the design trainee must obtain a good understanding of basic manufacturing processes, the types of equipment available for performing these operations, physical limitations of the equipment, setup and operation problems, and general quality expectations.

This experience can be expected to make him more conscious of the need for practical designs. Exposure to various tools and processes broadens his design base and permits him to call out substitute materials or processes, or to simplify a design for lower cost or high-speed production.

Assembly operations provide further opportunity for first-hand appreciation of design limitations. Good fits require precision machining and finishing which adds to the cost of the product. Knowing where and how to loosen up on dimensions without materially increasing assembly problems and costs is an important feature of his education.

Shop contacts also help develop an appreciation of how product design affects scheduling, materials

handling, raw materials requirements, inspection and quality control. There are so many additional advantages and lessons to be gained from exposure to production that the training period should be sufficiently long and broad to give the design engineer a thorough working knowledge of production tooling and processes. The shop is where the designer really learns to design.

Since this first stage is designed to bridge the gap between the academic and industrial atmospheres, the young engineer will require a period of adjustment to acclimate himself to his new surroundings. A good orientation program will materially assist him in making this adjustment.

The orientation process should be somewhat limited in the early stages of training. Rather than overwhelm the new employee with too many details, it would appear advisable to confine his introduction to the organization to those areas of immediate personal concern. Nevertheless no program would be complete without a rundown on the company's history and organizational makeup.

Every opportunity should be taken to familiarize him with the physical layout and activities of manufacturing, service, administrative and engineering facilities. Heavy emphasis, of course, should be placed on company policies, safety and personnel services.

Learning about the company's products is an important step in the trainee's indoctrination program, and is one that often precedes his assignment to actual design work. Products are the reason for the company's existence; they influence and govern everything the organization does.

This should be more than a casual exposure. The trainee should become intimately familiar with the product's function, application, design, materials, and method of fabrication. He should have opportunities to see where and how certain products are made and tested. This experience provides him with a better overall understanding of the purpose of his training and starts the process of making him design conscious.

Post-graduate training begins with introduction of formal coursework that leans heavily on work assignments. It has the advantage of pointing up the relationship between design and production and develops an insight for design economy early in his career.

The Second Stage

Here, the designer's activities become more directly related to design work. He has completed his shop training and is ready for assignment in the design division. He will have a lot to learn

Department	Aspects Pertinent to Design
Planning	1. Economical methods applications. 2. Easier materials handling. 3. Selection of materials for easier fabrication. 4. Inexpensive tooling and work-handling application. 5. Flexibility in selection of process equipment. 6. Tolerances which are easy to provide for and obtain.
Production Control	1. Encourages use of standard materials, stock parts and hardware. 2. Double checks to be certain no changes will be necessary after part is in production. 3. Checks designs for errors or omissions so that scheduling is completed without additional process requirements. 4. Allows the production department to burn up stocks which would otherwise have to be obsoleted before authorizing a design change. 5. Helps simplify scheduling by emphasizing design standardization and interchangeability.
Purchasing	1. Locates and selects reliable vendors. 2. Maintains adequate stock levels. 3. Stockpiles scarce materials. 4. Compiles shortage lists to permit materials substitutions. 5. Standardizes materials to reduce varieties on hand, capital tied up and chance of loss through obsolescence.
Research	1. Determines whether certain materials can be used for a particular design. 2. Finds physical limitations of a design. 3. Investigates how design stacks up under constant use. 4. Checks to see if the product meets basic safety requirements.
Inspection	1. Maintains a constant check on production to insure maintenance of product uniformity, design standards, and quality of workmanship. 2. Prevents shipment of substandard merchandise. 3. Detects serious design blunders early enough to save on scrap. 4. Tells designer whether plant can economically produce to his specifications. 5. Helps straighten out too severe limits and reduce manufacturing costs.
Sales	1. Engages in product styling and market research. 2. Keeps designs in step with changing times. 3. Checks designs with an eye to packaging and customer satisfaction. 4. Emphasizes designing for interchangeability. 5. Advises on spare parts needs.

before he is capable of taking on responsible assignments.

During this phase he will be brought into closer contact with the organizational departments whose activities his design affects and, in turn, whose services influence his design work. Besides manufacturing, the more important departments are:

1. Planning
2. Production Control
3. Purchasing
4. Research
5. Inspection
6. Sales

Indoctrination in the purposes and functions of these six departments is essential to the designer's continuing growth.

Introduction to company engineering standards brings out the following points:

1. That it is cheaper to make design changes before the part goes into production.
2. Design changes can cause tooling and stock obsolescence.
3. The importance of co-operating and co-ordinating with the various service divisions.
4. Importance of designing for customer acceptance.
5. Good sense about material substitution.
6. Design simplicity. Fewer parts mean simpler construction, lower manufacturing, assembly and repair costs.
7. Need for standardization and interchangeability for economical tooling and manufacturing.

With experience the designer learns to anticipate shop problems and plans to avoid them by making adjustments in the original design before it is let to production. Henry Ford's statement that the problems of production start on the drawing board are now quite meaningful to him.

Society activities—technical and professional—may now be suggested to the designer as broadening influences. Through them he keeps up with latest developments in design, material utilization, processes and industrial standards. Regular attendance at local section meetings helps enlarge his circle of acquaintances, lets him see what others are doing, offers an informal atmosphere where mutual problems can be discussed, and helps him make the proper professional contacts.

Management should give its wholehearted endorsement and support to his participation in section and national meetings. Wherever possible, he should be encouraged to take an active role in committee work, present papers and help with organization problems. Company funds and facilities should be made available for these activities.

Continued post-graduate education must also go on without letup. By this time he is ready to determine his own needs and select courses accordingly. Where educational facilities are available locally, management will find it profitable to provide the necessary incentives to encourage employees to work toward advanced degrees. Employees whose grades meet certain standards should have their tuition partially or wholly reimbursed, and appropriate entries should be made on their employment records. Where applicable, this information may be used as a basis for advancement. If educational facilities are not available locally, management should take the initiative to see what can be done to obtain them.

The Third Stage

This stage completes the designer's development program. By this time he will have acquired a certain amount of technical competence and professional reliability. He's now at the point where his assignments should become more demanding and responsible in character. As he demonstrates a capacity for leadership he should have every opportunity to supervise special projects.

Added responsibilities bring him into intimate contact with various technical and administrative staff operations, which helps him develop skill in dealing with people. Eventually he will make outside contacts with vendors and customers. How well he handles himself will be a strong factor in his advancement.

As he increases the range of his activities he will need to acquire additional skills and background. Management may find it necessary to send him to special schools to obtain the needed information. More than an investment in money and time, this is a reflection of management's confidence in him.

The Results of the Program

This article has spelled out what management needs to do to develop designers with these attributes:

1. Technical competence.
2. Seasoning.
3. Foresight, flexibility and originality.
4. Ability to work with people.
5. Ability to sell ideas and spread enthusiasm for their work.

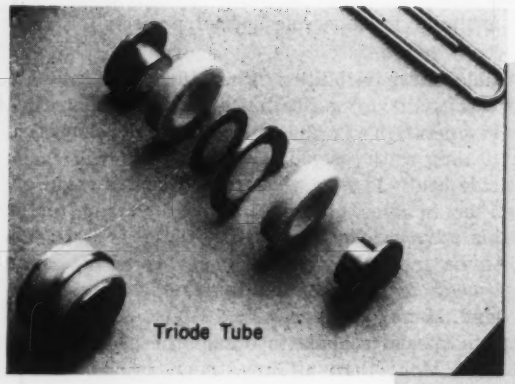
It would be nice if the story could end here. Unfortunately, too many designers are not being effectively used today. Careful matching of man and job means intensified and more personal interest in work assignments. Result of this interest will be better designs, lower personnel turnover, and improved competitive position.

How About Your Company's Program?

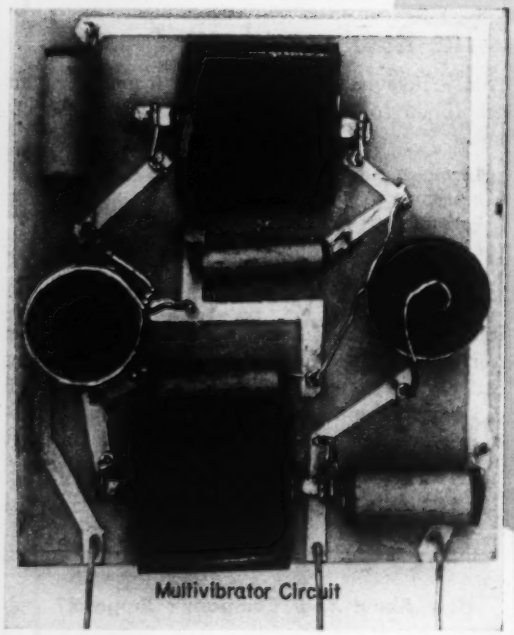
Does it differ from this one in method or philosophy? If so, the editors would like to learn about it. Your comments may prove of value to others. Write: Editor, *Machine Design*, Penton Bldg., Cleveland 13, O.

XUM

scanning the field for Ideas



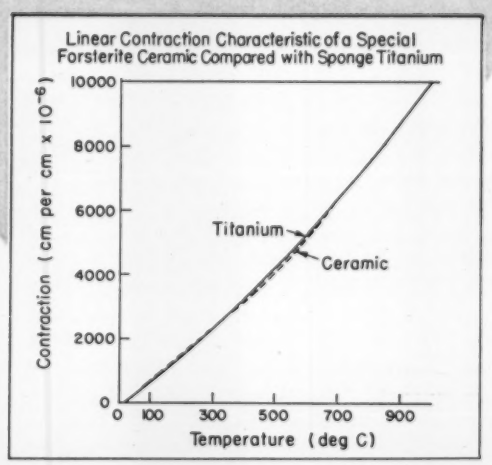
Triode Tube



Multivibrator Circuit

STACKED CONSTRUCTION OF ELECTRONIC COMPONENTS simplifies production and assembly problems. Employed by General Electric in their new line of electronic tubes, resistors and capacitors developed for extremely high-temperature environments, the design makes use of simple, symmetrically shaped titanium, ceramic and mica parts. Designed to operate over a wide temperature range, the ceramic materials used in the stacked assemblies have expansion characteristics closely matching those of titanium.

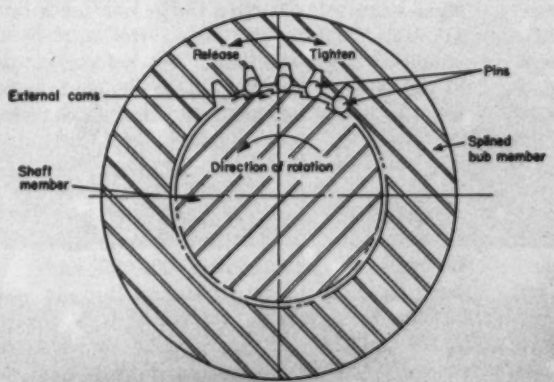
The titanium parts serve as resistor end caps, capacitor plates, tube anodes, grids, etc. The ceramic parts function as insulators and spacers, and special-design mica parts are used as dielectric materials in capacitors. Vacuum capacitors can also be made by use of the ceramic-titanium stacked design utilized in the vacuum tube, but maximum capacity is limited since the dielectric constant of a vacuum is unity.

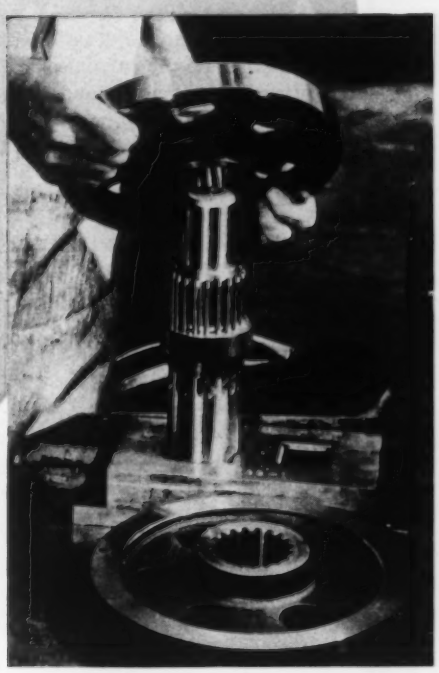


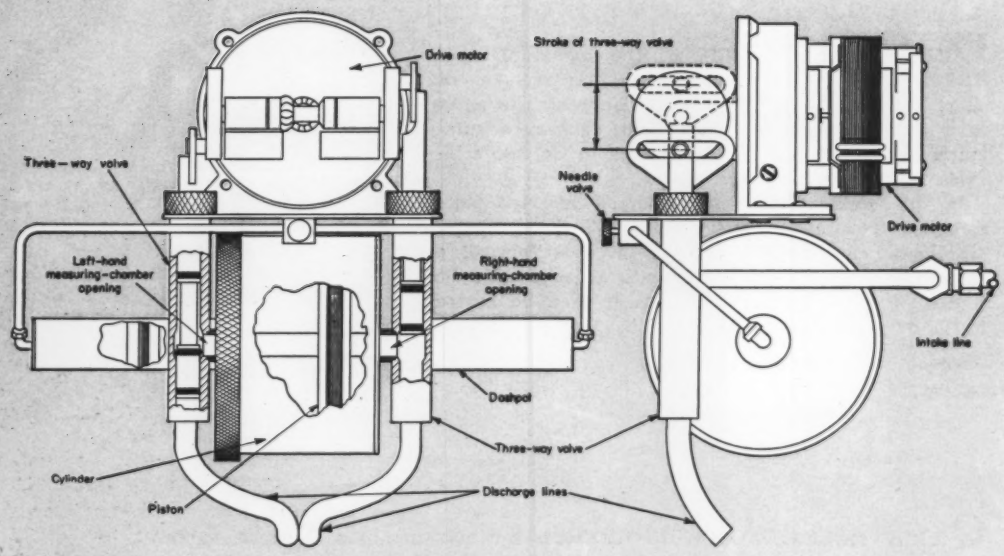
DIMPLED METAL TUBE SURFACES SIMPLIFY BRAZING of tight sleeve joints. Preplacement of short pieces of silver filler metal between the outer tube and dimples in the inner tube facilitates automatic brazing of tubular assemblies in Columbia bicycle frames.

In this application a short tubular inserted piece is coiled from a flat strip into a cylindrical shape. At the same time the tubular piece is formed, a dimple is pressed in each side with an automatic die punch. Pieces of brazing alloy can then be nested in the punched depressions.

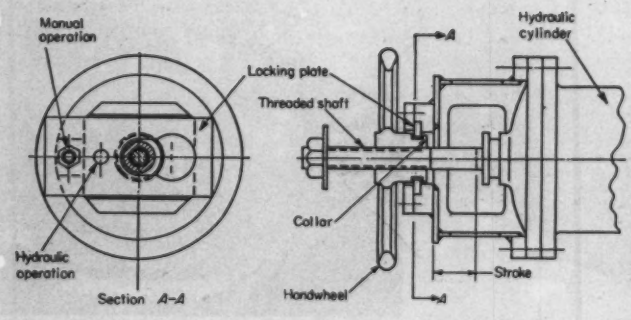
QUICK-RELEASE LOCKING METHOD for hub-mounted shaft assemblies eliminates keys or set screws. The design is applied in Scully-Jones pin type arbors developed for securely mounting splined-bore gear blanks. Locking is accomplished by rotating the hub member with respect to the shaft member. This action causes pins, which are regularly spaced around the shaft by means of a cage, to move up a series of ramp type cams on the shaft and to wedge securely into the splines in the hub. Cam rise is designed so pins remain in the locked position unless force is exerted in the opposite direction. Reverse rotation of hub unlocks the members.







ACCURATE CONTROL OF FLUID DISCHARGE is accomplished by a novel "positive-displacement" valve design. Developed by the Punxsutawney Co. for use in carbonated beverage dispensers, the valve mechanism is made up of three basic assemblies. There is a cylinder and piston for accurately measuring gases and liquids. Two dashpots with an adjustable needle-valve control govern speed of piston movement and flow of liquid through the cylinder. Two motor-driven three-way valves are incorporated in the unit to control direction of piston travel. When the port on the left-hand valve is open to the intake line, fluid under pressure flows into the left-hand chamber forcing the piston to the right. At the same time the port on the right-hand valve is open to the discharge line allowing fluid to flow from the right-hand chamber. The cycle is then reversed by means of the three-way valves, and right-hand chamber fills while left-hand chamber discharges.



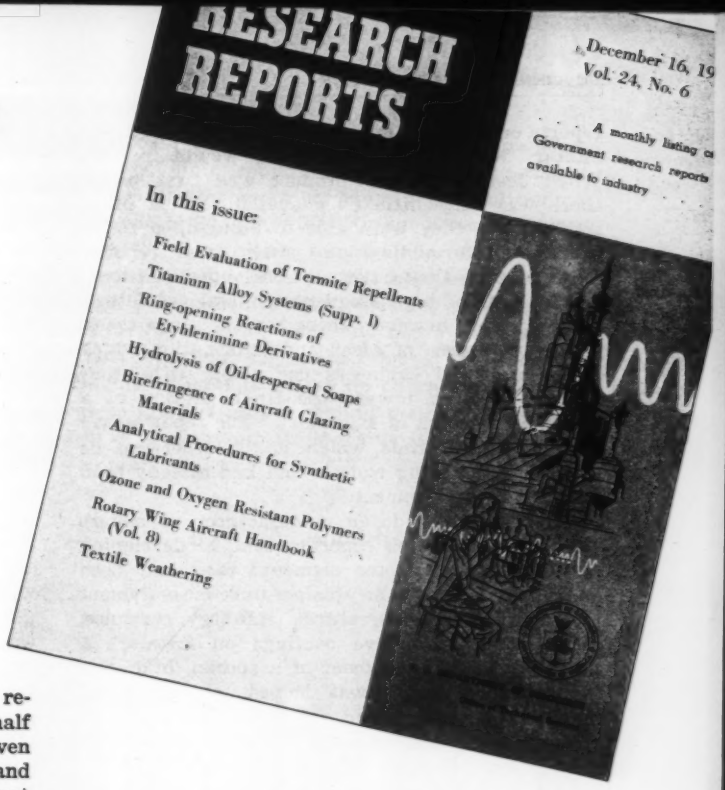
SLOTTED LOCKING PLATE permits manual or hydraulic positioning of hydraulic cylinders. Designed by Hans W. Hamm of York, Pa., the plate contains two round holes for locking it in the manual or hydraulic-operation positions. The large slot in the plate is designed to engage a collar on the handwheel whenever manual settings are desired.

Do you have a novel design idea for our other readers? You can receive ten dollars or more for each idea accepted for exclusive publication in this department. Send a short description plus drawings or photos to: "Scanning the Field for Ideas," MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Government Research Reports

—useful tools available to designers

By Edwin W. Still
Webster Groves, Mo.


RESEARCH REPORTS
December 16, 19
Vol. 24, No. 6
A monthly listing o
Government research reports
available to industry
In this issue:
Field Evaluation of Termite Repellents
Titanium Alloy Systems (Supp. I)
Ring-opening Reactions of Etyhlenimine Derivatives
Hydrolysis of Oil-despersed Soaps
Birefringence of Aircraft Glazing Materials
Analytical Procedures for Synthetic Lubricants
Ozone and Oxygen Resistant Polymers
Rotary Wing Aircraft Handbook (Vol. 8)
Textile Weathering

GOVERNMENT or government-sponsored research is estimated to be more than half of all the research done in this nation. Even though most of it is for the military agencies and much of it is classified, a great part of it is not classified (or has been declassified) and has direct application for peacetime industry. Research activities of the government extend into almost every field of industry, covering such subjects as metals, plastics, electronics, fuels, instruments, ceramics, and automation. Private industry is increasingly using the results of this research to engineer new products and processes.

Reports on much of the research and its results are easily obtained because Congress, in 1950, passed a law directing the Secretary of Commerce to set up a clearinghouse that would collect and distribute this valuable information. This is the Office of Technical Services of the U. S. Department of Commerce.

More than 250,000 different reports have already been cataloged and filed by OTS, and new reports are said to arrive at the rate of about a thousand a month. Recently the AEC added its collection of several thousand unclassified reports.

From all the reports it receives, the OTS selects the more important ones and reprints them for sale to the public. Originals of the other reports, which are considered so specialized that demand for them will not warrant the cost of printing, are deposited in the Library of Congress. There they may be inspected in the Annex Reading Room, or copies may be ordered in either photocopy or microfilm from the Library of Congress, Photoduplication Service, Publications Board Project, Washington 25, D.C., or through any of the Department of Commerce field offices. Prices of the reports are fixed to cover only the cost of reproduction and handling.

A survey of the purchases of these reports has been made by OTS to ascertain the use which the reports have been given. Sometimes the reports have actually resulted in the development of an end product. One company, for example, used

Translated from Zeitschrift für physik, 61: 655-659, 1930, by the American Meteorological Society under Contract AF 19(604)-1364.
1. Spectral lines - Broadening - Theory - Germany
2. Contract AF 19(604)-1364.

Generators, Motors, Transmission

Corona and dielectric losses in pulse-transformers. Final report for the period 1 Apr 1951 to 30 Apr 1954, under Contracts DA-36-039-sc-5552 and DA-36-039-sc-52659, by William G. Hoover. Stanford University. Dept. of Electrical Engineering. Ryan Laboratory, Stanford, Calif. May 1954. 63p photos, diagrs. Order from LC. MI $3.90, ph $10.80. PB 118804

Summary of activities on these two contracts, with Results of tests with different types of synthetic circuit are in close agreement with the theories put forward. The design of synchronized tripping circuits and other auxiliary equipment is described. Electrical engineering series vol. 6, no. 4. Sweden. Kungl. Tekniska Hogskolan, Stockholm. Handlingar nr. 87. Acta polytechnica 166.

FUELS AND LUBRICANTS

Burning velocities of various premixed turbulent propane flames on open burners, by Paul Wagner. U. S. National Advisory Committee for Aeronautics. Oct 1955. 32p photos, diagrs, graphs, tables. Order from National Advisory Committee for Aeronautics, 1512 "H" St., N. W., Washington

Section of a page from one of the monthly *U. S. Government Research Reports.*

reports on magnesium in designing an item for the military which cut the necessary weight in half. When design of their product was first begun there was very little data available from other sources, but they were able to build up a fairly comprehensive bibliography with these reports. More recently they have used the reports in their development of high frequency crystal oscillators.

More often, however, these reports serve as an important source of ideas and information which researchers and engineers use along with other sources in work toward the final solution of a problem or design of a product. The reports save costly research time which might otherwise be spent in duplicating work which had already been done for the government.

For instance, a large manufacturer of meters and control systems reported that in developing resistance thermometer elements they had been helped by reports on temperature-measurement techniques, high-temperature metallurgy, ceramics, and ceramic protective coatings on metals. A project in the development of a special, high-gain instrument amplifier was helped by reports on magnetic amplifiers, and the development of new electronic amplifiers was aided by reports on electronic circuit design and miniaturization.

One industrial concern was even led by the reports to increase its own research activity. The reports helped them consider new items to manufacture and increased their interest in research.

The reports themselves may be located through the card catalog in the OTS public reference room or through the subject bibliographies and the monthly abstract bulletins prepared by OTS. Each of the subject bibliographies—most of which cost ten cents at OTS—is an annotated list of the available reports on that subject with prices and full directions for ordering. Bibliographies are available on a wide variety of subjects including air conditioning and ventilation, circuit breakers, die-casting, induction heating, lubricants, and transitors. A complete list of subjects covered may be obtained from OTS or the field offices listed in the accompanying table.

Information on new reports which become available is presented in the form of abstracts in the monthly bulletin *U. S. Government Research Reports*. Each issue contains abstracts for some 300 to 400 reports gathered during the month, the price of each, and complete instructions for ordering. Subscriptions to the bulletin can be ordered for $6 a year from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. or from one of the Department of Commerce Field Offices.

A more detailed description of reports thought to be of special interest to small and medium-sized businesses is available in the monthly *Technical Reports Newsletter*. Each issue describes about fifteen or more reports and lists the new bibliographies available. Subscriptions at one dollar a year may be obtained as are those for USGRR.

The survey made by OTS revealed a number of ways various industries use the monthly USGRR. At the manufacturer of meters and control systems each issue is scanned thoroughly by the project engineers who select the reports to be ordered. In the research division of a large oil company the librarian scans each issue for reports that might be helpful and refers these abstracts to the particular researchers who are working on a related project. A manufacturer of offset printing machinery and other printing equipment and supplies circulates the monthly issues to six research people who mark the listings they desire.

OTS director John C. Green reported that last year American scientific organizations and industries purchased 64.8 per cent more government research reports through OTS than they did in 1954. This large increase in use of the reports indicates a growing awareness of their value as sources of technical information to people in research and development work.

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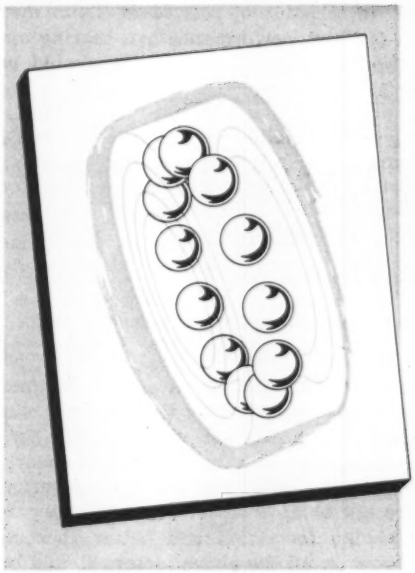

Applications requiring antifriction bearing operation at extremely high speeds over wide temperature ranges are becoming more common. Successful operation at speeds of 20,000 to 30,000 rpm at temperatures of −65 to 400 F or higher requires careful control of bearing construction, lubrication methods and lubricants.

This article is concerned with selection of the proper lubricant for high-performance ball bearings operating under such exacting conditions. Design of housings and lubricant systems to assure an adequate supply of lubricant as well as proper sealing methods were discussed in a previous article, Machine Design, Sept. 20,

By T. E. Rounds
Chief Engineer
The Barden Corp.
Danbury, Conn.

Selecting Lubricants For High-Performance Ball Bearings

PRIOR to World War II, except for a few military applications, there was little need for ball-bearing lubricants to operate over a temperature range much greater than 40 to 150 F, which is the extreme range of most shop equipment including high-speed grinding spindles. Military requirements at that time brought the low end of the range down to −40 F and the high end to somewhat above 300 F.

During and since World War II, ability to start equipment at temperatures as low as −65 F and operate at temperatures well above 300 F focused attention on the need for better lubricants. The trend to temperatures as high as 400 F and over, and planned new designs for temperatures as high as 800 F and over has created a need for superior lubricants.

OILS

For many years petroleum lubricants have satisfied the performance requirements of superprecision ball-bearing applications with a high degree of success for limited ranges of temperatures. A wide range of viscosities is available and, by suitable blending of refined oils from different crude sources, viscosity change with temperature can be reduced. Pour points also have been reduced, and resistance to oxidation and thermal stability have been increased. However, petroleum lubricants have serious shortcomings, if they are not altogether unsuited, for operation at temperatures of 400 F and higher.

Synthetic Fluids: During the 1940's work was done in this country and abroad to develop synthetic fluids having low pour points, minimum viscosity change with increasing temperature and better thermal stability at high temperatures. The shortcomings of petroleum oils—lowered viscosities at elevated temperatures for a reasonably low pour point, high evaporation, foaming and thermal instability at high temperatures—have in large part been overcome by certain new synthetic lubricants. Lubricating ability of some of these products, however, has been doubtful, particularly in the case of ball bearings running at high speeds.

The best of the synthetic lubricants are essentially homogeneous chemical fluids having definitely predictable and controllable physical and performance characteristics. Petroleum oils have been treated with additives to depress pour points and increase oxidation and corrosion resistance as well as film strength. Synthetic lubricants similarly

XUM

treated have proved to be superior to the petroleum products. Cost of the synthetics is high but their use is amply justified in many installations. Most prominent of these synthetics are:

1. **Synthetic Diesters:** These are reaction products of dibasic organic acids and alcohols. The MIL-L-17353, MIL-L-6085 and MIL-L-7808 types, Table 1, are of this composition. These oils have excellent stability and good viscosity-temperature characteristics. Oxidation and corrosion resistance is excellent. The 6085 and 7808 types are best for high temperatures up to 400 F and for short periods up to maximum limit of 500 F. Main objection is adverse effect on certain plastics, paints and elastomers. The 6085 is preferred (except where gears are involved), since it has less tendency to sludge at elevated temperatures.
2. **Silicone and Silicate Ester Fluids:** These are complex organic compounds classed as methyl silicones, methyl phenyl silicones and silicate esters. They are outstanding for their resistance to oxidation and have unusually good viscosity-temperature characteristics. A wide selection of viscosities and pour points is available. Their main use is for hydraulic systems. Main disadvantage is poor lubricity for steel-on-steel rolling and sliding contacts, limiting their usefulness in ball bearings to a DN value (D = bearing bore, mm; N = rpm) of 200,000 or less and at light loads of 1/3 of catalog rating at speed. Slow-moving instrument applications such as gear trains with light loads have been successful with some of these fluids. Much development work is underway and improvements are expected.
3. **Organo-Phosphate Esters:** These also are complex reaction products of alcohols and phosphoric acid. Main usage has been in hydraulic systems, but authorities have indicated preference for diester oils where loads and speeds are high, particularly as temperatures pass beyond 400 F.

Selection: In selection of petroleum oils or synthetic fluids for high-performance ball-bearing applications, the following characteristics should be considered:

1. Viscosity characteristics over expected temperature range.
2. Pour point.
3. Evaporation rate.
4. Oxidation resistance.
5. Thermal stability.
6. Corrosion resistance.
7. Ability to lubricate a ball bearing operating under moderate to heavy loads and at high speed.

Viscosity is a measure of flow rate and therefore pumpability. Viscosity is usually tied in with pour point to a degree; the lighter viscosity oils generally have the lowest pour points. Furthermore, the higher viscosity oils have lower evaporation rates and are apt to have better resistance to oxidation and sludge formation and better thermal stability. However, all the above factors should be checked, since certain types of oils do not have all of the most desirable characteristics.

LOW-TORQUE, LOW-SPEED APPLICATIONS: For low-torque, low-speed applications petroleum oils have largely been superseded by synthetic diester oils of the MIL-L-6085 type. A newer synthetic fluid with much lower viscosity, MIL-L-17353, designed for predominant cold conditions should be a very promising solution for problems encountered with certain types of airborne or ground equipment where little warm-up is experienced. Need for this lighter fluid will be dictated largely by speed, as shown by recent checks which have indicated that gyro gimbal torque is little affected until viscosities in the range of 2000 to 5000 centistokes are encountered. As speed increases the restraining torque due to the oil becomes apparent. But a much more serious effect at low temperatures is frosting, due to traces of

Table 1—Characteristics of Some Petroleum and Synthetic Oils

Item No.	MIL Spec or Commercial Type	Oil Type	Pour Point, Approx (F)	Viscosity, Approx —65 F (ssu)	—65 F (cs)	100 F (ssu)	100 F (cs)	210 F (ssu)	210 F (cs)	400 F (cs)	Corrosion Resistance	Oxidation Resistance	Rate of Evaporation	Operating Range (F)
1	MIL-L-17353	Dibasic ester	—75	5600	1200	44.7	5.75	32.6	1.9	..	Excellent	Excellent	Moderate	—65 to 250
2	MIL-L-6085	Dibasic ester	—75	56000	12000	71.7	13.5	37.6	3.4	1.3	Excellent	Excellent	Low	—65 to 400; above 400 for short periods.
3	MIL-L-7808	Dibasic ester	—75	60600	13000	74.3	14.2	38.2	3.6	1.4	Excellent	Excellent	Low	—65 to 400; above 400 for short periods.
4	MIL-O-6081* (1010)	Petroleum	—70	65000	14000	58.8	10.0	32.8	2.0	..	Good	Good	Moderate to high	—65 to 300
5	Light spindle	Petroleum	—25	.....	.....	100	20.5	39.4	4.0	..	Good	Good	Low to moderate	Pour pt to 200
6	Turbine	Petroleum	0	.....	.....	150	32.0	43	5.1	..	Good	Good	Low to moderate	Pour pt to 250
7	Turbine	Petroleum	10	.....	.....	220	47.4	48	6.7	..	Good	Good	Same	Same
8	Turbine	Petroleum	20	.....	.....	880	190	78	15.0	..	Good	Good	Same	Same

*Largely superseded by the dibasic esters.

Table 2—Selection Guide for Fluid Lubricant Application

Application	Temperature Range (F)	Speed, Max (*DN*)	Load	Lubricant	System	Enclosure
Gyro gimbals, Autosyn motors, Servomechanisms, Computers & Scales	—75 to 150 (predominantly cold)	10,000	Usually negligible	MIL-L-17353	Initial application, one to several drops	Shielded bearing or open bearing with cap, usually enclosed in system
	—65 to 200 (predominantly hot)	10,000	Same	MIL-L-6085	Same	Same
Gyro rotors	140 to 200	200,000	Axial preload, 1/5 to 1/2 rating at speed	Item 8, Table 1	Initial vacuum impregnation of phenolic ball retainer including film on bearing parts	In sealed system with inert or nonoxidizing gas atmosphere
	—65 to 250	200,000	Axial preload, 1/5 to 1/2 rating at speed	MIL-L-6085 oil plus MIL-G-3278 grease	Vacuum impregnation of phenolic retainer with oil followed by grease pack	Shielded bearing in sealed system with inert or nonoxidizing gas atmosphere
Machine-tool and woodworking spindles	40 to 150	400,000+	Mainly axial preload as recommended for speed	Items 5, 6 or 7, Table 1	Wick or drip	Labyrinth and cap
				Items 5 or 6, Table 1	Air-oil mist	Same
Aircraft and other gear drives	—65 to 400 and over for short periods	400,000+	Light to moderate	MIL-L-7808	Spray, high-speed bearings	Enclosed with labyrinth or contact seal
			Heavy	Same	Flow or drip, low-speed bearings	Same
Turbine-driven units (no gears)	—65 to 400 and over for short periods	400,000+	Light to moderate	MIL-L-6085	Wick-fed air-oil mist	Labyrinth and cap, contact seal if necessary
			Heavy	Same	Spray	Same

moisture. More ample quantities of oil inhibit this action.

Not all torque problems at low temperatures are due to the lubricant, however. Designs should be carefully checked for thermal contraction effects, particularly with dissimilar materials such as aluminum housings with steel bearings and shafts. Bearings which are excessively cramped or loaded internally due to thermal material effects may show torque build-up far greater than that due to the lubricant viscosity alone.

For continuous rotation at speeds of a few hundred rpm and over, grease lubrication is usually preferred unless extremely sensitive action is required for near-zero rpm conditions.

HIGH-SPEED, NORMAL-TEMPERATURE APPLICATIONS: For high-speed above 600,000 *DN* at temperatures of 40 to 150 F where use of oil or fluid lubricants is necessary for drip and wick-fed systems, oils having viscosities of 100 to 200 Saybolt seconds at 100 F are universally used. For air-oil mist systems, petroleum oils within the range of 50 to 150 Saybolt seconds at 100 F are found suitable. Turbine and spindle oils, Table 1, are typical of those used for these applications. Most spindle manufacturers have worked out recommended feeding rates in drops per minute for drip feed and air-oil fog systems. Important precautions to observe are:

1. Make certain that all bearings receive lubrication and that air flow patterns do not overlubricate one bearing at the expense of another.
2. Make certain that foreign matter is kept out of bearings. Air-oil mist pressure systems generally are most efficient in this respect, but air flow patterns developed by improperly designed slingers may have tendencies to suck in foreign matter. Slingers should have equal diameters at each end of the housing and seal clearances should be equalized.
3. Make certain air is clean and dry. Water separators and dust filters should be included in the air piping as close to the spindle housing as possible.

Of course, quality lubricants with such additives as are recommended by reliable suppliers to inhibit oxidation and corrosion should be used. Extra cost of premium oils is more than offset by longer bearing operations, less frequent replacement, and lowered overall operating cost.

HIGH-SPEED, WIDE-TEMPERATURE-RANGE APPLICATIONS: This type of application is encountered very frequently in aircraft accessories, usually in turbodrives, but at times in gear-drives. Speed range runs from *DN* values of 500,000 to 1,000,000 and over. Temperature extremes are —65 to 400 F. Military specifications have generally dictated use of low pour-point synthetic fluids to permit rapid low-temperature starts. Because of the high speeds and the heavy loads which are sometimes encountered, the diester oils of the 6085 and 7808 types are used. Preference is indicated for the 6085 type except when the same oil must lubricate gears.

High-speed, high-temperature tests conducted by many users and suppliers indicate that above 400 F the lubricant situation is quite critical, particularly in terms of long life. In this temperature range, phenolic laminate ball retainers cannot be used, and their superior qualities of ease of lubrication and minimum tendency to wear under boundary lubricant starvation conditions cannot be utilized. Much work has been done to provide metallic ball retainers which have minimum weight as well as maximum wear qualities, maximum heat transmission characteristics, and best exposure of balls to the lubricant. Definite operating improvements have been achieved along these lines by bearing manufacturers.

In spite of all attempts to meet current problems, no end seems to be in sight on requirements for higher and higher temperatures of operation. Viscosities are down to about 1 centistoke for the

MIL-L-6085 and MIL-L-7808 type fluids now available. One should note that this viscosity is about the same as that of water at 68 F and that reliable machine tool spindles running at similar speeds are using oils having viscosities in the 10 to 32 centistoke range.

The question as to whether higher viscosities at elevated temperatures of synthetic fluids will or will not yield longer life remains to be settled. Much patient and careful investigation will be necessary because of the many complex factors involved. Attainment of higher viscosity at high temperatures without sacrificing cold test properties will be a challenge to the synthetic fluid chemists, but should ease the problem of obtaining lower evaporation rates and better thermal stability. The increase in energy loss and higher heat generation of higher viscosity oils will be a challenge to the equipment designer who has his problems with vanishing heat sinks.

The fact remains, however, that increase of viscosity usually has developed more reliable film lubrication characteristics particularly in those cases where viscosities have been unusually low. This improvement has shown up mainly on gear wear tests but should improve ball bearing endurance as well, provided the additional energy losses due to higher viscosities can be dissipated to maintain reasonable temperatures. Studies are now being actively pursued in this direction. Much depends on the design of individual units and permissible or possible heat rejection factors.

Some units have been developed requiring operation at high speeds and under very cold temperatures where lower viscosity oils are needed in order to achieve proper wick feed action. It is apparent that reliable synthetic lubricating fluids are needed with both lower and higher viscosity characteristics than those presently available.

GREASES

Greases have been known to man for thousands of years, mainly as thickened oils compounded to promote adherence to moving parts and thereby solve the problem of retention in a simple and realistic manner. This compounding has been largely by rule-of-thumb rather than on the basis of true scientific study and formulation. In recent years, however, largely due to the requirements of civil and military aviation activities the relatively crude products of 30 years ago have been vastly improved. The increasingly general use of ball and roller bearings in all classes of moving devices has also focused attention on the scientific approach to problems of formulation and quality control. Increasing speeds and temperature ranges have

Table 3—Characteristics of Some Petroleum and Synthetic Greases

Item No.	Military Spec or Commercial Type	Usual Basic Compound	Cold Test (F)	Dropping Point (F)	High Temp Test (F)	Oxidation Resistance	Corrosion Resistance	Water Resistance	Speed, Max (*DN*)	Operating Range (F)	Remarks
1	MIL-G-7421 grease; extreme low temperature	Diester oil; lithium soap	—100	325	250	Good	Good	Excellent	500,000	—100 to 200	Extreme low temperature use
2	Silicone-urea type	Silicone oil; aryl urea thickener	—90	600	400	Excellent	Fair	Fair	200,000	—90 to 400	Low to high temperature, light loads
3	MIL-G-15793 grease; instrument	Diester oil; lithium soap	—65	340	...	Good	Good	Excellent	400,000	—65 to 250	Low to moderate high temperature
4	MIL-G-3278 grease; instrument	Diester oil; lithium soap	—65	325	250	Good	Good	Excellent	400,000	—65 to 250	Low to moderate high temperature
5	MIL-L-7711; general purpose aircraft	Petroleum oil; mixed soap	—40	350	250	Good	Good	Good	600,000	—40 to 250	Low to moderate high temperature
6	MIL-G-15719 grease; high temperature	Silicone oil; lithium soap	0	375	300	Excellent	Fair	Good	200,000	0 to 300	High temperature, light loads
7	MIL-L-3545 grease; high temperature	Petroleum oil; soda-calcium soap	....	350	300	Excellent	Good	Fair	500,000	0 to 300	High temperature, short periods above 300 F
8	Silicone-urea type	Silicone oil; aryl urea thickener	—40	600	450	Excellent	Fair	Fair	200,000	—40 to 450	High temperature, light loads
9	High-speed, high temperature	Synthetic oil; sodium soap	....	380	400	Good	Good	Good	600,000	—40 to 350	Good at low and high temperatures*
10	Spindle-bearing grease	Petroleum oil; metallic soap	....	300	...	Fair	Fair	Fair	600,000	0 to 200	Moderate - temperature, high-speed grease

*At —40 F has lower torque than Item 7 at 0 F.

Table 4—Selection Guide for Grease Lubricant Application

Application	Temperature Range (F)	Speed, Max. (*DN*)	Load Condition or Limit	Grease Lubricant	Enclosure
Gyro rotors (low-temperature start)	−100 to 200	500,000	Mainly preload, 1/5-1/2 of thrust rating at speed	MIL-G-7421	Cap or shielded bearing, preferably sealed in inert gas
	−65 to 250	400,000	Same	MIL-G-15793 MIL-G-3278	Same
Small motors, servos, small precision devices (low-temperature start)	−100 to 200	500,000	Moderate loads	MIL-G-7421	Cap, shielded bearing, unit usually enclosed in system
	−65 to 250	400,000	Same	MIL-G-15793	Same
	−90 to 400	200,000	1/3 of rating at speed	MIL-G-3278 Item 2, Table 3	Same
	−40 to 450	200,000	Same	Item 8, Table 3	Same
Machine-tool spindles and small power tools	40 to 150	600,000	Thrust preload, as recommended for speed conditions	Item 10, Table 3 MIL-L-7711	Cap closure and labyrinth seal
Aircraft gear drives also general application	−40 to 250	600,000	Moderate loads	MIL-L-7711	Cap and/or labyrinth seal as needed
	0 to 300	500,000	Same	MIL-L-3545	Same
	−40 to 400	600,000	Same	Item 9, Table 3	Same
High-temperature electric motors	−40 to 300	200,000	1/3 of rating at speed	MIL-G-15719	Open or shielded bearing with cap enclosure and/or labyrinth seal as needed

made it necessary to use high-quality raw materials carefully compounded to maintain quality, and to develop better thickening agents and additives.

As with petroleum oil lubricants, the synthetic base fluids made their appearance as the result of research in the 1940's. Prior to World War II there was little need for lubricants with operating temperature ranges in excess of about 0 to 200 F. Good mechanical and storage stability were primary assets as well as corrosion resistance and chemical stability in this temperature range. Most thickening agents were soaps of the sodium and calcium type or mixtures of these two.

Early in the 1940's use was made of lithium soaps compounded with light petroleum oils which met for a limited period the need for good plasticity down to −65 F and performed reasonably well at temperatures somewhat above 200 F. Excessive evaporation of the low pour-point light petroleum oils forced the development of compounds of lithium soap with diester oils.

The military type grease, MIL-G-3278, proved to be an improvement since temperatures of 250 F could be handled for longer periods. Lithium stearate compounded with diester oil has excellent cold test properties. Some typical greases of this composition are listed in Table 3.

The next development, silicone oils compounded with lithium stearate soaps, proved to have superior viscosity characteristics over a wide temperature range and has lower evaporation and excellent oxidation resistance. Unfortunately, the limitations of silicone oils—speedability less than 200,000 *DN* and load-carrying ability of less than ⅓ of catalog rating at speed—are present. Latest development is the use of aryl urea thickeners which extend temperature range to above 400 F. Properties of some of the silicone oil greases are given in Table 3.

Grease Selection: Two predominant fields of application for greases exist. In nonmilitary and nonaircraft applications, operating temperatures range from about 40 to 150 F. In aircraft and military applications the operating range is much broader, taking in temperatures of −100 to 450 F.

Most important requirements for greases used for ball-bearing lubrication are:

1. **Cold Test:** Plasticity at low temperature as evidenced by torque and time for a revolution of a specific bearing. Reflects ability to start devices having low output torque characteristics.
2. **Mechanical Stability:** Evidenced by limited change in consistency (penetration values) after mechanical working. Related to stability of gel structure and ability to retain lubricant in the bearing.
3. **High Temperature Endurance:** Ability to lubricate a bearing at elevated temperature for a specified period and speed without failure or high torque rise.
4. **Corrosion Resistance:** Ability to provide rust protection to bearings.
5. **Water Resistance:** Ability to withstand water wash. This is of most importance where bearings are poorly protected against weather influences.
6. **Oxidation Stability:** Ability to resist exposure to oxygen and temperature for period of time. This does not always correlate with dynamic performance tests.
7. **Storage Stability:** Ability to withstand idle storage without material change in consistency; such as excessive hardening in bearings.

Other tests involving dirt count, dropping point, evaporation, oil separation and gear wear are often used for specific purposes to insure inherent excellence and/or performance quality under adverse military conditions.

Severity of these tests has developed a screen which excludes to a great degree poor lubricants which otherwise would cause serious service difficulties. Nonmilitary users therefore can reap considerable benefit from use of these products for those more exacting applications running at high speeds or temperatures.

SELECTION FOR TEMPERATURE AND SPEED RANGE:

Spindle bearing grease, Item 10, Table 3, is an excellent lubricant for the range 0 to 200 F and speeds to 600,000 *DN*. It is compounded for low initial temperature rise and is somewhat unique in this respect. Another typical type also good for the same speed is the general-purpose aircraft grease, Item 5, Table 3.

For wider temperature ranges, such as −65 F to 250 F, several products qualify, notably the diester-oil, lithium-soap instrument grease which may be used for *DN* values of 400,000. Another type, MIL-G-7421, is good for an even wider range of temperatures and is usable at speeds as high as 500,000 *DN*.

For high temperatures, that is up to 300 F, MIL-L-3545 is considered good, since speed factor is high. Another excellent high-temperature grease is the MIL-G-15719 type. However, the silicone oil content limits this product to slow-speed equipment, such as general-purpose motors running at 3500 rpm maximum with bearings to about 50 mm bore size. For larger bearings speeds are even lower.

SELECTION FOR APPLICATION: If typical applications, such as gyroscope rotors, are considered, the MIL-G-7421, MIL-G-15793 and MIL-G-3278 greases are preferred since bearings are small, usually below 8 mm bore, and operate at speeds of 24,000 rpm and under. These products develop no adverse wear factors in ball bearings. Temperatures for such applications are in the range of −65 F to 250 F maximum, but may be expected to increase at the high end.

For small motors to meet 400 F ambients, satisfactory performance in cases where speeds do not exceed about 15,000 rpm and bearing sizes average around 3 to 5 mm bore is given by the urea type silicone products, Table 3. However, the high-temperature, high-speed grease problem has not been completely solved, particularly for large size bearings.

Specific mention should be made of a new high-speed, high-temperature product, Table 3, No. 9, which appears to have some very encouraging properties. While its low-temperature torque is not as low as some of the other greases, there are certain applications, such as the larger airborne turbine accessory units, where low-temperature torque is not critical due to rapid warm-up factors. The high-temperature endurance properties of this product are excellent.

A selection guide for specific application in summary form, Table 4, can be very useful. It should be noted, however, when using such a guide that greases work best under moderate load, speed and temperature conditions. If load is heavy and speed and temperature are well within the capability of the grease, life can be reckoned in terms of thousands of hours if bearings are properly selected and applied. However, if all three factors are high, very limited life may be experienced even below a few hundred hours.

Conclusion: The ultimate test of reliability of any lubricant in a given piece of equipment is the overall performance test of the unit itself. Inevitably, results of such performance tests, depend upon many factors. Most important of these are:

1. Load, radial (including unbalance components) and thrust.
2. Speed.
3. Temperature range.
4. Air flow across bearings, causing starvation of lubricant.
5. Mounting variables including adverse conditions of:
   a. Misalignment.
   b. Radial or axial constraint—parasitic preload of uncontrolled amounts, sometimes due to uncontrolled heat expansion of bearing inner ring.
6. Adverse conditions of vibration and shock.
7. Foreign matter contamination—liquid, solid, benign or abrasive.
8. Corrosive influences.

Often the complicated cross influences of these factors make evaluation of lubricant differences extremely difficult. Bench tests of simulated conditions make the comparative evaluation of different lubricants simpler, but correlation with actual equipment operating conditions may at times be poor for these reasons.

Many tests have shown wide dispersions of individual test life in terms of time. Maximum and minimum life may vary in a wide range, requiring a degree of statistical analysis in order to show the proper picture. Main hope lies in continued reduction of the number of variables which adversely affect bearing life to the end that performance tests, whether in bench type simulated equipment or in actual full-scale equipment, will produce answers of a repetitive and reliable nature.

The crucial point that is reached by all available lubricating fluids or greases is thermal stability at elevated temperatures. Considerable work is being done by leading research organizations along this line as well as toward reducing temperature-viscosity changes.

Tips and Techniques

It may often be necessary to interpolate between a family of curves to obtain a desired parameter. A piece of acetate sheet with ten equally spaced pin holes punched in it has proved to be very handy for this use. Holes are about 0.1-in. apart. By lining up the first and the tenth holes on two curves, intermediate values are easily read. The same sort of gadget may be made for use with logarithmic curves by varying hole spacing logarithmically. — LEROY PAYNE, *Lockheed Aircraft Corp., Burbank, Calif.*

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A PAPER FROM THE
THIRD CONFERENCE ON MECHANISMS

Basic factors in CAM DESIGN

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THE CAM is one of the most versatile means for fulfilling the many requirements of machines. This is true because of the infinite variations in the kinematic properties of displacement, velocity, acceleration, and pulse. The term *pulse* identifies the slope of the acceleration curve (da/dt) or, as some authors call it, jerk. Control of all these properties determines the smoothness of performance, especially at high speeds.

Since the cam is a surface in contact with the follower, it may have any shape and, also, it may be fixed, or it may translate, rotate, or oscillate. In low-speed, light-weight, relatively rigid follower linkages, the cam may be simple to construct, requiring very little refinement of contours. A smooth "bumpless" curve may fulfill the requirements. But as either the mass, speed, or elasticity of a linkage increases, a detailed study must be made of both the theoretical aspects of the cam curve and the accuracy of cam fabrication. One factor cannot be considered without the other since the performance of the mechanism is obviously affected by both.

One of the first conditions in design is the cam size. The cam size is basically affected by the pressure angle or steepness of the cam profile, curvature or "sharpness" of the curve and size of the cam shaft. The pressure angle influences the side thrust of a translating roller follower in its bearing guide. The cam curvature, if too small, gives excessive stresses, and the cam-shaft size determines the minimum cam size. Cams too large are unfavorable owing to space limitations, higher surface speeds, longer paths of follower movement and greater wear. A small cam is generally desirable.

Pressure Angle: In a cam-follower system, the pressure angle is significant in establishing the performance, torque, loads, wear, life, and other factors. Note that pressure angle is the angle between a normal to the cam surface and the instantaneous direction of follower motion. Its significance is in its relationship to the follower force

Table 1—Cam Factors for Basic Curves

Basic Curve	Cam Factor f
Straight-line	$\cot \alpha_m$
Simple-harmonic	$(\pi/2) \cot \alpha_m$
Parabolic	$2 \cot \alpha_m$
Cycloidal	$2 \cot \alpha_m$
Cubic No. 1	$3 \cot \alpha_m$
Cubic No. 2	$(3/2) \cot \alpha_m$

α_m = Maximum or limiting pressure angle.

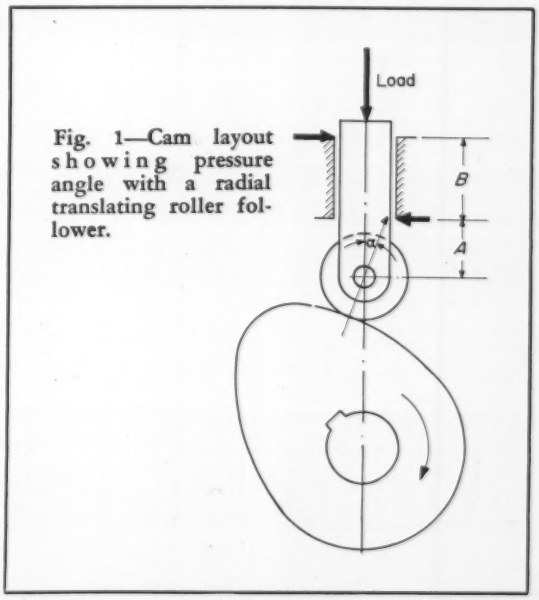


Fig. 1—Cam layout showing pressure angle with a radial translating roller follower.

Table 2—Equations for Basic Cam Curves

Curve		Displacement y (in.)	Velocity $v = dy/dt$ (in./sec)	Acceleration $a = d^2y/dt^2$ (in./sec^2)	Size Ratio
Simple Polynomial					
Straight-line		$\frac{h\theta}{\beta}$	$\frac{h\omega}{\beta}$	0, ∞ at ends	1
Parabolic or constant-acceleration	$\frac{\theta}{\beta} \leqq 0.5$	$2h\left(\frac{\theta}{\beta}\right)^2$	$\frac{4h\omega\theta}{\beta^2}$	$\frac{4h\omega^2}{\beta^2}$	2
	$\frac{\theta}{\beta} \geqq 0.5$	$h\left[1-2\left(1-\frac{\theta}{\beta}\right)^2\right]$	$\frac{4h\omega}{\beta}\left(1-\frac{\theta}{\beta}\right)$	$-\frac{4h\omega^2}{\beta^2}$	
Cubic No. 1 or constant-pulse No. 1	$\frac{\theta}{\beta} \leqq 0.5$	$4h\left(\frac{\theta}{\beta}\right)^3$	$\frac{12h\omega}{\beta}\left(\frac{\theta}{\beta}\right)^2$	$\frac{24h\omega^2}{\beta^2}\left(\frac{\theta}{\beta}\right)$	3
	$\frac{\theta}{\beta} \geqq 0.5$	$h\left[1-4\left(1-\frac{\theta}{\beta}\right)^3\right]$	$\frac{12h\omega}{\beta}\left(1-\frac{\theta}{\beta}\right)^2$	$-\frac{24h\omega^2}{\beta^2}\left(1-\frac{\theta}{\beta}\right)$	
Cubic No. 2 or constant-pulse No. 2		$h\left(\frac{\theta}{\beta}\right)^2\left(3-2\frac{\theta}{\beta}\right)$	$\frac{6h\omega\theta}{\beta^2}\left(1-\frac{\theta}{\beta}\right)$	$\frac{6h\omega^2}{\beta^2}\left(1-\frac{2\theta}{\beta}\right)$	1.5
Trigonometric					
Simple-harmonic		$\frac{h}{2}\left(1-\cos\frac{\pi\theta}{\beta}\right)$	$\frac{h\pi\omega}{2\beta}\sin\frac{\pi\theta}{\beta}$	$\frac{h}{2}\left(\frac{\pi\omega}{\beta}\right)^2\cos\frac{\pi\theta}{\beta}$	1.6
Cycloidal or sine acceleration		$\frac{h}{\pi}\left(\frac{\pi\theta}{\beta}-\frac{1}{2}\sin\frac{2\pi\theta}{\beta}\right)$	$\frac{h\omega}{\beta}\left(1-\cos\frac{2\pi\theta}{\beta}\right)$	$\frac{2h\pi\omega^2}{\beta^2}\sin\frac{2\pi\theta}{\beta}$	2
Double harmonic		$\frac{h}{2}\left[\left(1-\cos\frac{\pi\theta}{\beta}\right)-\frac{1}{4}\left(1-\cos\frac{2\pi\theta}{\beta}\right)\right]$	$\frac{h\pi\omega}{2\beta}\left(\sin\frac{\pi\theta}{\beta}-\frac{1}{2}\sin\frac{2\pi\theta}{\beta}\right)$	$\frac{h}{2}\left(\frac{\pi\omega}{\beta}\right)^2\left(\cos\frac{\pi\theta}{\beta}-\cos\frac{2\pi\theta}{\beta}\right)$	...

Nomenclature: h = maximum rise of follower, in.; β = cam angle rotation for rise h, radians; θ = cam angle rotation for displacement y, radians; ω = cam angular velocity, rad per sec.

distribution which is a consideration only when the follower moves opposite the direction of its load.

With flat-faced followers, the pressure angle force distribution rarely is of concern. With oscillating roller followers, the distance from the cam center to follower pivot center and the length of the follower arm are pertinent to this study. Often for ultimate performance frequent trials must be made by layout to establish the best dimensional proportions under the given design conditions. With the popular translating roller follower, the pressure angle determines the side thrust and wear of the follower stem in its bearing guide. The conventional method of controlling the forces on the follower under these circumstances is to arbitrarily limit the pressure angle to 30 degrees. The limiting pressure angle, Fig. 1, for a radial translating roller follower is

$$\alpha_m < \tan^{-1} \frac{B}{\mu\,(2A + B)} \qquad (1)$$

where B = bearing guide length, in.; A = overhang of follower stem, in.; and μ = coefficient of friction of follower in its bearing.

It should be noted that Equation 1 is based upon the assumption that all members are rigid. Thus, the value of maximum pressure angle α_m found with this equation should be reduced somewhat depending on the elasticity of the follower stem and the clearance between the stem in its guide bearing. Other parameters are governed in accordance with Equation 1. Note that commercially available linear ball bearings with their limited backlash have been utilized in increasing the allowable pressure angle of the mechanism. Futhermore, since the cam size and pressure angle are related, we can show for the cylindrical cam and also by approximation for the radial cam that the pitch circle radius is

$$R_p = \frac{fh}{\beta} \qquad (2)$$

where R_p = distance from the cam center to the point of maximum pressure angle of the roller center, in.; f = cam factor for the particular basic curve and pressure (Table 1); h = total rise of the follower, in.; β = cam angle of rotation for rise h, radians.

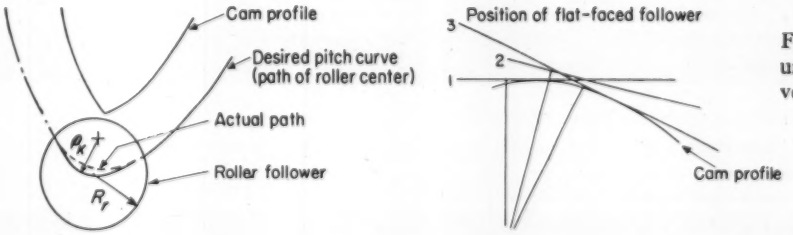
With Equation 2 and Table 1, the cam size for a limiting pressure angle can be established prior to layout. This method of determining cam size will usually save much time in contrast to the trial-and-error method of layout.

Curvature: In cam-profile curvature analysis, a detrimental condition called *undercutting* may occur. Undercutting means inadequate cam curvature giving incorrect follower movement. Generally the cam condition approaching undercutting gives high stresses and low cam life. Undercutting on a cam may occur with either the roller follower or the flat-faced follower.

Fig. 2*a* shows the construction for a roller follower on a convex curve with undercutting. When the radius of curvature ρ_k of the pitch curve is less the roller radius R_r, a cusp or sharp point results. Obviously, with the roller running on this cam, the path of the roller center is no longer along the desired pitch curve shown. In Fig. 2*b*, with the flat follower, undercutting may also occur. That is, position 2 on the cam profile does not exist. With the flat-faced follower undercutting generally is the only limiting condition in cam size since the pressure angle has no significant effect.

To alleviate the conditions of either undercutting or sharp corners, the following courses are apparent: With a roller follower, use a small roller. This has limited practical value because of the undesirable stresses that may be induced because of the smaller roller size. In all cases the easiest approach to prevent undercutting is to use a larger cam. This, of course, is often impractical since a larger machine results.

A more refined approach to this problem leads to a relationship between the follower acceleration and the curvature of a cam. As an example, a convex cam having a pitch curve radius equal to the roller radius is shown in Fig. 3. The cam profile has a sharp corner with the actual motion of the follower center being a curved path in which



(*a*) Roller follower (*b*) Flat-faced follower

Fig. 2—Examples of undercutting on a convex cam.

instantaneous movement of the roller follower is an impossibility. The follower acceleration may be increased by using a smaller roller. We see that the radius of curvature of the pitch curve is related to the follower acceleration.

As shown previously for a convex cam, to prevent undercutting the radius of curvature of the pitch curve $\rho_k > R_r$, which yields

$$\frac{\left[(R_a + y_m)^2 + \left(\frac{y_m'}{\omega} \right)^2 \right]^{3/2}}{(R_a + y_m)^2 + 2 \left(\frac{y_m'}{\omega} \right)^2 - (R_a + y_m) \left(\frac{y_m''}{\omega^2} \right)} > R_r \qquad (3)$$

where y_m = displacement of follower at the point of maximum negative acceleration, in.; y_m' = velocity of follower at the point of maximum negative acceleration, in. per sec; y_m'' = acceleration of the follower at the point of maximum negative acceleration, in. per sec^2; ω = cam speed, radians per sec; R_r = follower roller radius, in.; R_a = radius of smallest circle to roller center, in. Also, for a flat-faced follower to preclude undercutting, the radius of curvature of the cam profile is

$$\rho_c = R_b + y_m + \frac{y_m''}{\omega^2} > 0 \qquad (4)$$

where R_b = base circle radius, in.

Basic Dwell-Rise-Dwell Curves: The most popular method in establishing the cam shape is by first choosing a basic curve such as parabolic, simple-harmonic or cycloidal. These curves, which are of critical significance in establishing control of the follower movement, are easy to construct and analyze. Generally, the actual cam shape is not considered. However, some designers with moderate cam speeds find that replacement of the final cam shape with accurately located circular arcs reduces cost of machining and, at the same time, maintains control of the acceleration curve within satisfactory limits. However, at high speeds this application of circular arcs is not recommended because of the abrupt change in the acceleration curve at the blending points.

Basic curves are primarily of two families: the simple polynomial and the trigonometric.

As a comparison between these two families, the trigonometric curves — simple harmonic, cycloidal and double harmonic curves — give better overall performance than polynomial curves — straight line, parabolic, and cubic. The former give smaller cams, lower follower side thrust, cheaper manufacturing cost, easier layout and duplication. Thus, they are applied for higher speeds. A summary of the equations and comparisons of the curves is given in Table 2.

The cam size ratio in Table 2 gives a comparison for cams of the same pressure angle with the straight-line profile as a basis. In Fig. 4 the curves are superposed for a comparison of characteristics.

The straight-line curve is poor at any speed due to large "bump" at the ends. It is not suggested for use with dwells at either end. Of course, this curve may be improved by adding a blending arc at the dwell ends.

The *parabolic* curve would be excellent, with perfectly rigid members and no backlash or clearance in linkages. But since this is not the case and whether a compression spring or positive-drive follower is used, this curve gives poor performance. Its use should be limited to moderate speeds. It is poor in wear, pressure angle, spring size, etc., as compared to the trigonometric curves.

Cubic No. 1 is not practical due to large cam size. In addition, unusually high accuracy of cam cutting at the dwell ends is necessary and may offer difficulty.

Cubic No. 2 has characteristics similar to the simple-harmonic curve.

The *simple-harmonic* curve is easy to construct and calculate and also gives a reasonable cam follower action at moderate speeds. The sudden change in acceleration at beginning and end of action precludes its high-speed application. However, this curve gives low follower side thrust, smooth starting and a reasonable follower spring size, compared to the basic polynomial curves.

The *cycloidal* curve is the best of all contours if the accuracy of machining can be maintained at the beginning and end of stroke. It gives lower vibration, and less wear, stress, noise, and shock. It is easy starting, requires small springs and the side thrust of a translating roller follower is low. Therefore, it is recommended for high speeds.

The *double-harmonic* curve is somewhat similar to the simple-harmonic curve with the additional advantage of theoretically smoother action at the start. However, this is at the expense of a larger

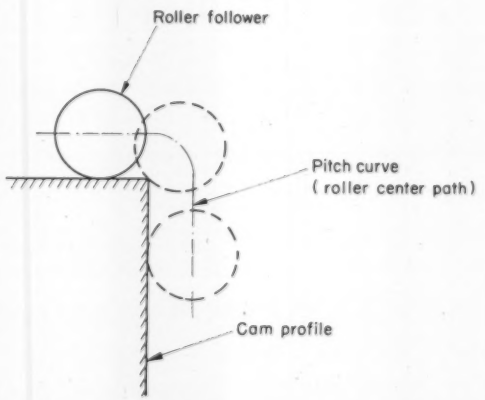


Fig. 3—An extreme case showing how acceleration of follower is influenced by pitch curve and follower roller radius.

cam for a reasonable pressure angle and cam curvature. Also, cutting at the initial points of the curve requires accuracy of such order that it is usually a machining impossibility. The double-harmonic curve is used to best advantage with a dwell-rise-return-dwell cam. In that application, lower vibration, favorable wear, easy start, low follower side thrust, and small spring size result. In general, the fabrication problem at the ends and acceleration at the maximum-rise point generally preclude its use as a dwell-rise-dwell cam.

Advanced Curves: Some of the usual requirements for high-speed cam action are small spring size, large cam curvature, long wear life, and low shock, noise, and vibration. Often the basic sym-

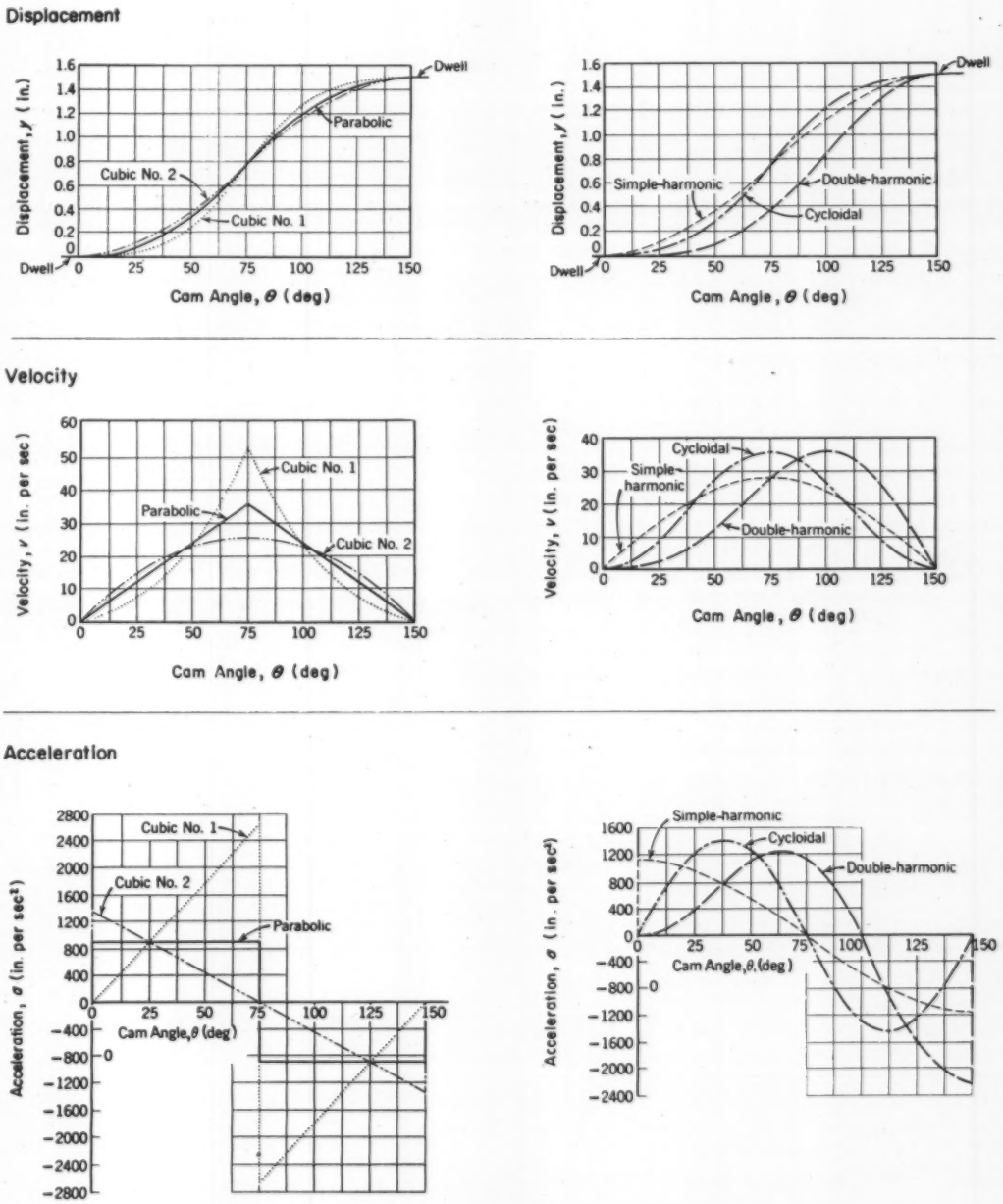


Fig. 4—Comparison of basic curves. Cam rotates at 300 rpm and follower moves 1½ in. in 150 degrees of cam rotation (0.0833 sec).

metrical curves such as parabolic, simple-harmonic and cycloidal are inadequate because the specific design requirements of the machine often dictate a cam action that cannot be obtained with the basic curves. To fulfill the requirements and also control the dynamic properties of the cam, pieces of these basic curves have been combined to advantage.

The primary condition for these *combination* curves is that there must be no discontinuity in the displacement, velocity and acceleration curves. In other words, the displacement, velocity and acceleration at the points of intersection, as determined by the separate basic curves, would best be equal. In addition, the acceleration curve should not have too great a slope.

Often, as the specific machine requirements are increased, the combining of these curves becomes mathematically too involved. This is especially true with dwell-rise-return-dwell cams. Therefore, other direct curve-fitting methods employ polynomial equations of the form,

$$y = C_0 + C_1\theta + C_2\theta^2 + C_3\theta^3 + \ldots \qquad (5)$$

where y = displacement of the follower, in.; θ = angle of cam rotation for rise y, degrees or radians; C = constants.

Sometimes, with special designs, the manipulation of the polynomial equations opposes the basic functional requirements of the cam, such as large valve opening in automobile cam linkage. In this case, some designers use the method of starting with the curve and, by trial and error combined with past experience, find the desired cam shape using electronic computers to perform the increment integration. As a summary of advanced curve choice, the automobile and aircraft designers are employing an unsymmetrical cam acceleration curve in which the maximum positive acceleration is three to four times the maximum negative acceleration, Fig. 5. This is a high-speed cam giving minimum spring size, maximum curvature of cam and thus longer surface life.

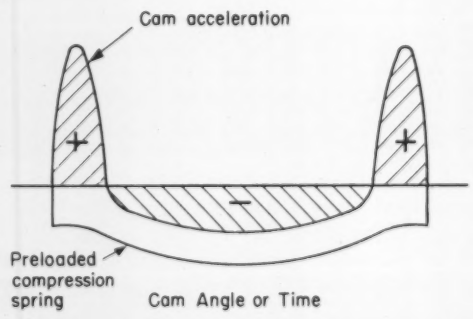


Fig. 5—Typical high-speed cam curve used for automotive or aircraft engine valve system.

High-Speed Cams: In cam-follower systems, vibrations of some sort are always induced. At low speeds vibration is rarely of concern, but at high speeds it becomes a serious condition. Due to the elasticity and mass of the follower linkage, the follower does not move exactly as the cam shape dictates. The follower in this case means the end

Table 3—Design Recommendations for High-Speed Cam Systems

1. Keep the maximum acceleration values of the cam as small as possible to give small inertia loads. That is, use the maximum time and the minimum throw or movement of the follower.
2. Maintain finite values of pulse (or jerk), the slope of the cam acceleration curve, to eliminate or reduce high stresses, high vibrations and resonance. In other words, the cam acceleration curve should be a continuous function. The best value should approach that of the cycloidal curve at the dwell ends of the action.
3. In general, use the cycloidal cam curve to fulfill the requirements of most dwell-rise-dwell machine problems if it can be made to the required accuracy. The modified trapezoidal cam acceleration curve having lower maximum acceleration values may be an improvement. Both are excellent choices for low follower vibration.
4. Make parts as rigid as possible; i.e., keep flexibility to a minimum. In some situations, laminated plastics, carbides, or other newer materials may be feasible improvements.
5. Make the moving parts of the machine as light as possible. Use materials such as aluminum or titanium, if practical. In both 4 and 5, a high natural frequency of the follower linkage is an objective.
6. Be certain that cams are cut accurately in accordance with the theoretical contours so that benefit from the mathematics is not lost. Surface finish and accuracy of fabrication are of prime importance. Keep small surface errors to a minimum. Because of surface imperfections, the actual cam dynamic characteristics rarely agree with the mathematical or theoretical ones.
7. Hold backlash in parts to a minimum. For example, use preloaded bearings.
8. Keep follower overhang to a minimum, and follower bearing guide length to a maximum. These factors allow a larger pressure angle and contribute to smoother action and a smaller cam.
9. Use low-friction bearings and lubricate all mating surfaces.
10. Balance the cams with intelligent proportioning of mass.

of the linkage, such as the valve in an automobile cam gear. Vibrations are important with high speeds, low stiffness, high mass, and resonant harmonic conditions.

The general expression for any follower system subjected to a cam forcing function is

$$My'' + by' + ky = F(t) \qquad (6)$$

where M = equivalent mass of follower linkage, lb-sec^2/in.; b = damping factor in linkages, lb-sec/in.; k = equivalent spring constant of the linkage, lb per in.; y = follower displacement, in.; y' = follower velocity, in. per sec; y'' = follower acceleration, in. per sec^2; $F(t)$ = periodic disturbing force as a function of time (cam contour), lb.

Solution of Equation 6 in terms of follower response will give its displacement, velocity and acceleration. For example, if the linkage were perfectly rigid, the follower response y would be the same as the cam contour displacement, y_c, and no vibration would be induced in the system. On the other hand, the follower response may be excessive if the follower linkage has a low natural frequency. In this case, chatter in positive drive cams and jump in spring-loaded cams result.

Theoretical and practical design considerations for high-speed cam follower performance are summarized in Table 3.

Polydyne-Cam Systems: An excellent approach to high-speed, highly flexible systems such as textile machines and automobile valve gear is provided by the polydyne method of cam design. Its shortcomings are the time consumed in establishing the cam shape, and occasional difficulty in fabricating the profile. This method recognizes that the elasticity of a system cannot be eliminated or reduced. The cam shape is designed from the desired follower motion taking into account this flexibility. In other words, by direct calculation the exact position of the follower is controlled. Theoretically, by this approach, no vibration exists at the designed speed. It is primarily a constant-speed method. Running at other than design speed is not suggested since strong harmonics of the cam profile may approach the natural freuency of the linkage and thus produce high vibratory amplitudes. By the polydyne method, the basic equation for the shape of the cam profile is

$$y_c = r + ky + cy'' \qquad (7)$$

where r = ramp height, the initial deflection of the follower linkage to the point where motion of follower end (such as valve) is impending, in.; k = equivalent spring rate ratio of follower linkage, lb per in.; c = dynamic constant; y and y'' = displacement and acceleration, respectively, of end of follower mass in polynomial form of Equation 5.

We see that the second derivative of the end mass displacement in Equation 7 gives the cam displacement y_c. High-speed dwell-rise-dwell cams require finite pulse values at the ends of the curve. This demands a polynomial equation possessing powers of 5, 6, 7, 8, 9:

$$y = 1 - 126\,\theta^5 + 420\,\theta^6 - 540\,\theta^7 + 315\,\theta^8 - 70\,\theta^9 \qquad (8)$$

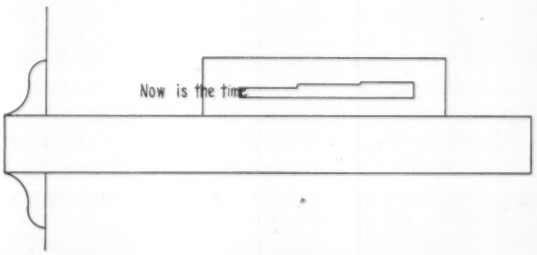
Equation 8 expresses the relationship for unit rise in unit time.

This article was presented as a paper at the Third Conference on Mechanisms, Purdue University, May 24-25, 1956. The Conference is cosponsored annually by the Purdue School of Mechanical Engineering and MACHINE DESIGN. Copies of the 38-page *Transactions* containing the five formal Conference papers are available for $1.00 each from: Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Tips and Techniques

Lettering Nameplate

Lettering can be kept neat and guide lines dispensed with if a lettering template cut from plastic is used. Lettering is done inside the template



with the pencil just touching the edges at top and bottom of the letters. Lettering can be vertical or slanted. As many slot widths as the number of letter sizes used may be cut.—ROBERT E. FARNHAM, *Naperville, Ill.*

Finding Irregular Areas

Irregularly shaped areas can be found by ruling the area to be measured into vertical strips and then measuring the height of the strips with a specially constructed scale when a planimeter is not available. As an example, if the area were ruled into ¼-in. wide spaces, the scale made of a transparent material such as tracing paper or plastic might have graduations ¼-in. apart which would represent 1/16 sq in. increments. Readings taken at the midpoint of the ¼-in. wide segments could then be read directly as areas. Readings could then be summed on an adding machine. This method eliminates some of the probability of errors in counting squares when such an area is drawn on graph paper or ruled into squares.—H. BELOFSKY, *New York, N. Y.*

Using Stainless Steels

The mechanisms of corrosion are complex and difficult to predict. The designer must combine intelligently all the information available, published data on corrosion rates, materials characteristics, and his own past experience. In addition it is highly advisable to perform corrosion tests under expected service conditions.

Some of the most useful tools available today for combatting corrosion are the stainless steels. This family of metals provides a wide choice of mechanical and physical properties to meet almost any situation. However, the designer must choose wisely from the many grades and intelligently design his structure to make the best use of these important metals.

FOR EQUIPMENT that must operate in corrosive situations, the designer can select materials from a large and growing family of stainless steels. These metals offer a variety of physical and mechanical properties in addition to their corrosion resistance. They are capable of high strengths at extreme temperatures. They are easily fabricated, durable and noncontaminating. Perhaps most important of all, they hold the prospect of longer operating life than most materials.

As a guide to designers, this article describes kinds of corrosion and types of stainless steel. It also summarizes considerations to prevent corrosion in the design, fabrication and operation of stainless steel products.

Types of Stainless Steel

There are approximately 37 standard grades of stainless steel. They all contain at least 11.5 per cent chromium, often 7 per cent or more nickel, sometimes molybdenum, columbium, tantalum, titanium, and others.

Since chromium is the basic alloying element for inducing passivity in stainless steels, corrosion resistance is generally improved by increasing the chromium content up to a certain point. Oxidizing conditions favor passivity; reducing conditions, and the presence of chloride ions cause liability to attack.

Additions of nickel tend to improve various mechanical and welding properties. They also raise the corrosion resistance of the steel to alkalies, neutral chloride ions and acids of low oxidizing capacity.

Molybdenum adds even greater corrosion resistance to stainless steel, particularly in various hot organic acids, sulfurous and sulfuric acid, and pitting resistance in neutral chloride solutions, such as sea water. It is also influential in increasing creep strength.

Columbium (or columbium-tantalum) and titanium additions help avoid intergranular attack that may occur to stainless steel after operating in the sensitizing range of 800 to 1600 F, or after welding.

The 300 Series: Stainless steels in the 300 series are austenitic in structure and are basically ferro alloys of chromium and nickel. They offer excellent resistance to corrosion and mechanical wear, a high order of fabricability and wide selection of types to meet specific conditions.

Type 302 is the basic alloy of the group. It is the stainless type most generally used because of its balance of properties which include good corrosion resistance, high strength, especially in the cold-worked condition, fabricability and durability. It

for Corrosion Resistance

By Richard Paret,
Stainless Steel Specialist
American Iron and Steel Institute, New York

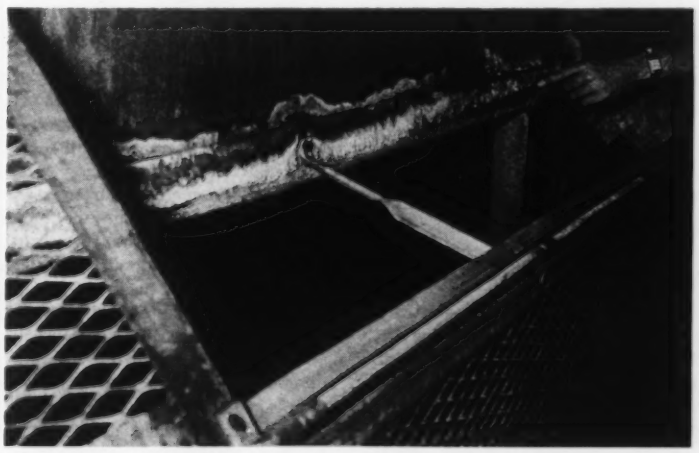
has excellent resistance to nitric acid and other oxidizing agents. On the other hand it is less resistant to most acid salt solutions, and heavy metal halide solutions, such as $FeCl_3$, may cause pitting. Equipment made of Type 302 and operating in the sensitizing range or welded without subsequent annealing may be liable to intergranular attack if exposed to corrosive environment. Usually, another type of stainless should be chosen to meet these conditions.

Variations upon the basic Type 302 include Type 301, which is capable of being cold worked to extremely high strength and is often used in transportation equipment. Type 301 has excellent resistance to atmospheric corrosion, but can be considered to have less general corrosion resistance than Type 302. Further variations upon the basic Type 302 include Types 303, and 303 Se, which are free-machining grades. In general the 303 types are slightly less resistant to corrosion than Type 302, but the difference is scarcely measurable under most conditions.

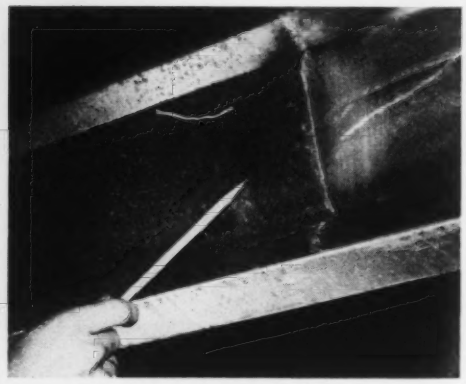
High temperature applications may occasionally call for Types 309 or 310, which contain higher amounts of chromium and nickel and are used for their scale resisting properties and their strength at elevated temperatures. The higher amount of alloying elements present in these types may increase their corrosion resistance somewhat, but if this is the only requirement, molybdenum-bearing stainless steels are preferred.

Reduced carbon content in stainless steel is useful in combatting intergranular corrosion that may occur after the metal has been heated in the sensitizing range during, for example, welding, and subjected to certain corrosive media. Carbide precipitation is assumed to be the cause of this vulnerability. Although annealing at proper temperatures will return the carbides to solution, there are occasions when this is impractical. Types 304 or 304L, containing maximum carbon contents of 0.08 and 0.03 per cent, respectively, are often used when welding or hot forming of Type 302 cannot be followed by annealing. Low carbon versions of Types 309 and 310 are available: namely Types 309S and 310S. Likewise, Type 316 has a low carbon version, known as Type 316L.

It should be noted, however, that precipitated



Atmospheric environment has caused severe crevice corrosion on this ordinary steel cooling tower. Note crevice corrosion at faying surfaces, at the lapped joint and under the bolt heads. The atmosphere of industrial areas can be strongly corrosive.



Danger signs are heavy accumulations which form galvanic cells, may in time cause pitting. Fine stainless steel wool and scouring powder were used on cleaned portion of this doffer reel in a textile plant.

carbides do not always limit the use of equipment. Furthermore, certain processes may "donate" carbon to the alloy. In such cases it is needlessly expensive to specify a controlled carbon grade.

The so-called stabilized grades, Types 321, 347 and 348, are the conventional choice if the low-carbon types are considered not sufficiently resistant to attack after the equipment is used in the sensitizing range or if thick, complicated sections must be welded and kept hot for some time. Type 321 contains titanium, and Types 347 and 348 contain columbium and tantalum, the combination being held to 10 times the carbon content, by weight, with the tantalum limited to 0.1 per cent maximum in the case of Type 348. These elements help eliminate chromium carbide precipitation, since they have a greater affinity for carbon than does chromium.

It should be remembered that these types have corrosion resistance similar to Type 302 and that their greatest usefulness is in equipment that must be held in the sensitizing range for some time. And while they are often useful when extremely complex weldments must be made by straight arc welding without subsequent annealing, in general they

Definitions

Galvanic Corrosion: A typical example of this type of corrosion is two dissimilar metals electrically coupled in the presence of an electrolyte. The anode in the couple is diminished, since it releases metallic ions into solution. Freed electrons flow to the cathode, where they unite with hydrogen ions to form hydrogen. An accumulation of hydrogen may polarize the cathode and tend to retard the action. Dissolved oxygen in the electrolyte may combine with the hydrogen, depolarizing the cathode and renewing the process. The rate of arrival of oxygen at the cathodic surface is a strong control on the rate of galvanic corrosion. Usually the cathode is not corroded by the process. However, there are circumstances when the products of corrosion may attack the cathode.

The metal at the cathode is assumed to be the more noble metal. The degree of nobility of metals is indicated by the galvanic series, which can be used to predict most reactions under corrosive conditions.

Passivity: The exact nature of passivity in metals is not yet fully defined. For the purposes of this article it is sufficient to say that in a passive state a metal is more noble than in the active state and can better resist corrosion. The mechanism is variously ascribed to an adherent oxide film, changes in electron configuration, adsorbed gases, or a combination of these. For simplification, the presence of an adherent oxide film will be assumed.

In stainless steels, which are well-known for their passivity, this oxide film is thought to be rich in chromium and is self-renewing, transparent, tough, and highly resistant to chemical attack. In the passive state, the stainless steels are among the most noble metals, such as silver, gold and platinum. At the other end of the series are magnesium, zinc and aluminum, among others, which are highly anodic to stainless.

Pitting: Corrosion pitting, characterized by rapid penetration in small areas, may occur with any metal. It is the prevalent form of corrosion with the passive metals and under certain circumstances may occur in the absence of any other corrosion. Characteristic of pitting is a breakdown of the passive surface film at favored nuclei, such as a nonmetallic inclusion or under some deposit. An electrolytic cell is formed, having a minute anodic area where the "break" occurs, surrounded by a large cathodic area. The current density at the anodic or active area is consequently large, and the penetration may proceed quickly. Adding to the rapidity of the process is the activating (passivity-destroying) properties of the corrosion products within the pit and the relatively large amounts of oxygen available to the cathode for depolarization.

Other factors affecting pitting are temperature, aeration, flow and pH factor. Increases in temperature tend to increase pitting. A good flow of well-aerated solution tends to decrease pitting by insuring even passivity and potential levels, and by carrying away destructive corrosion products.

Pitting is one of the more difficult corrosion processes to evaluate or measure. In general, the stainless steels are resistant to pitting in most environments. However, the presence of chloride ions may cause them to pit in certain environments, such as stagnant sea water.

Crevice Corrosion: Degradation of a metal may occur adjacent to or under a crevice, such as a lapped joint. It can be described best as the formation of a galvanic cell. A difference in oxygen concentration may cause the area under the crevice to become anodic or active. Crevice or contact corrosion, as it is sometimes called, may occur in

should not be considered merely because welding is to take place. Usually a low carbon type will then be far more economical.

The molybdenum-bearing stainless steels, Types 316 and 317, have in general the greatest corrosion resistance of the standard grades. They have in general excellent resistance to such media as sulfurous acid, sulfuric acid, phosphoric acid, formic acid, and various hot organic acids. Resistance to pitting is substantially bettered. Moreover they have the highest creep strength of any of the standard stainless steels.

When equipment fabricated from Type 316 is used with sulfuric concentrations between 5 and 80 per cent, inhibitors such as ferric sulfate are recommended under conditions of high temperature.

Type 317, which is richer in alloying elements than Type 316, is even more resistant to corrosion. Type 316L is available for welding, but should not be used when service temperatures are over 800 F.

The 200 Series: The newest family of stainless steels is the 200 series, consisting so far of Types 201 and 202. They can be considered as counterparts of Types 301 and 302, having similar mechanical and physical properties. Austenitic in structure, they have substantially more manganese and less nickel. It has been predicted that Types 201 and 202 will replace their counterparts in the majority of applications where 301 and 302 are used today if shortages of nickel continue. Corrosion resistance of the 200 series is generally equal to or in some cases slightly less than their counterparts. Consequently the general guide for their application is that they should not be used where Types 301 and 302 are considered marginal.

The 400 Series: Basically Cr-Fe alloys, the 400 series alloys contain little or no nickel. Like the austenitic stainless steels they are outstanding in their resistance to oxidizing media. They are more likely to be attacked in service involving corrosive solutions under deaerated or reducing conditions. They are also more susceptible than the austenitic grades to pitting in the presence of halogen ions, particularly chlorides, even in neutral or alkaline solutions.

However, they are far superior to ordinary steel

a variety of circumstances, such as under surface deposits, marine growths, rivet or bolt heads, washers, "protective coatings" and others.

Intergranular Corrosion: The exact nature of intergranular corrosion, wherein a severe attack occurs along the grain boundaries of a metal, is still under investigation. It can occur to almost all metals under specified conditions. In some stainless steels that have been heated for a length of time in the range of 800 to 1600 F, intergranular corrosion may occur.

In the latter metals the mechanism is sometimes ascribed to a precipitation of chromium carbides, which can occur at these temperatures, along the grain boundaries. As a result the area adjacent to the boundary is depleted in chromium. Conditions are thus set up for a galvanic cell in which the impoverished grain boundaries are anodic to the interior of the crystal. Means for reducing or eliminating this attack are described in this article.

Stress Corrosion Cracking: Failures of a metal ascribed to stress corrosion cracking are the result of a combination of stress and corrosion, in which an intergranular attack or pitting may act as a stress raiser at the point of failure. The presence of tensile stress, often near the yield point, is assumed. This stress may be residual, such as the result of uneven shrinkage, from rivets or bolts, or it may be the result of the applied load. Stress corrosion cracking has been observed in all metal systems. Yet for each metal, stress cracking is associated with specific environments—often one which will attack the metal only superficially where stresses are absent. Chlorides are most frequently associated with stress corrosion cracking in stainless steels, especially in hot concentrated solutions or where dilute solutions have become concentrated by evaporation in splash zones or in crevices.

Corrosion Fatigue: Sometimes called the dynamic analogue of stress corrosion cracking, corrosion fatigue is the result of the concurrent action of cyclic stressing and corrosion. Like stress cracking, pits and intergranular corrosion act as stress raisers. No metal is immune from some reduction of its resistance to cyclic stressing if it is corroded by the environment in which it is stressed. It is useful to note that a metal's resistance to corrosion fatigue depends largely upon its resistance to corrosion. Other factors which exert a marked influence upon corrosion fatigue are the nature of the corroding medium, nature and range of stress, rate of stressing, temperature, degree of aeration, and physical properties of the metal, particularly its notch sensitivity.

Fretting Corrosion: Surface damage that occurs when two surfaces are in vibrating contact under high loads is often called fretting corrosion. The initial mechanical wear is accelerated by corrosion and its products. Reduction of slippage by increased friction and exclusion of corrosive environment by lubrication tends to reduce fretting corrosion.

Impingement and Erosion Corrosion: Impingement and erosion corrosion are apparently different degrees of the same basic phenomena —the eroding action of fluid at high velocity. Impingement corrosion is generally associated with turbulent flow; erosion attack is often associated with the abrasive action of liquids or gases. Since the removal of protective oxides or films is apparently involved in the process, it would seem to follow that metals with highly adherent films would be more resistant to this attack. The stainless steels have an exceedingly tough surface and stand up well in many eroding situations, such as turbine blades.

in many characteristics. They have a high degree of resistance to atmospheric corrosion; are more resistant to scaling during heat treatment; have greater strength, damping capacity, hardness and abrasion resistance. In the last instance, they are well-known for their resistance to impingement and cavitation corrosion, some grades having found excellent application in turbine blades and pump impellers.

Stainless steels in the 400 series are either hardenable by heat treating or are nonhardenable. The former are *martensitic* in structure; the latter are *ferritic*.

The martensitic stainless steels—Types 403, 410, 414, 416, 416Se, 420, 431, 440A, 440B, 440C—have high enough carbon-to-chromium ratios to undergo the necessary transformations for hardening by heat treating. When hardened they have exceedingly good wet or dry erosion and abrasion resistance and tensile strengths up 200,000 psi. It is important to note that they have their best mechanical as well as corrosion-resisting properties in the hardened and tempered condition.

Type 410 is the basic alloy of the martensitic types, having a balance of properties usually associated with this group. Type 410 has fair resistance to corrosion and is used more for industrial equipment, where its environment is controlled, rather than consumer goods, where it could receive considerable abuse. Types 440A, 440B, 440C have the highest hardness of the martensitic types. They are extensively used in high quality cutlery, ball bearings, and surgical instruments. Type 431 has the highest corrosion resistance of the martensitic types.

The ferritic stainless steels Types 405, 430, 430F, 430F Se, 446 have relatively low carbon-to-chromium ratios and are thus not hardenable to an appreciable extent. The higher chromium content of the 430 types and Type 446 make them generally superior to the martensitic grades in resistance to corrosive attack. Type 430, the basic alloy in the series, has been successfully used in many applications ranging from nitric acid production, fractionating towers, other chemical equipment, and to exterior architectural sheathing and automobile trim.

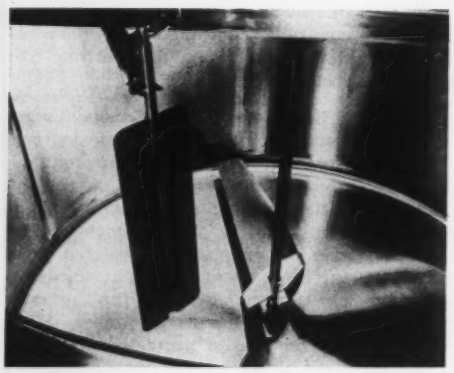
Type 405 has a relatively low chromium content and is therefore often considered to be one of the so-called 12 per cent chromium types. A low carbon content and added aluminum reduce the hardenability of this steel, giving welded areas that do not air-harden too much and remain satisfactorily ductile. Its primary use is for welded assemblies operated at temperatures below 1200 F. that cannot be annealed after welding.

Type 446 has a high chromium content, 23-27 per cent, and is often used where resistance to oxidation or to corrosion from sulfur-bearing gases at high temperatures is important.

Table 1—The Galvanic Series

Metals toward the top of this series are less noble than those toward the bottom and tend to corrode when in galvanic content. The effect of passivation in moving the stainless steels toward the noble end of this series is also illustrated.

Less noble	Inconel (active)
ANODIC END	Brasses
Magnesium	Copper
Magnesium alloys	Bronzes
Zinc	Copper-nickel alloys
Aluminum, 1100	Monel
Cadmium	Silver solder
Aluminum, 2017-T	Nickel (passive)
Iron and carbon steel	Inconel (passive)
Copper steel	Stainless Type 410 (passive)
4-6 per cent Cr steel	Stainless Type 430 (passive)
Stainless Type 410 (active)	Stainless Type 446 (passive)
Stainless Type 430 (active)	Stainless Type 301 (passive)
Stainless Type 446 (active)	Stainless Type 302 (passive)
Stainless Type 301 (active)	Stainless Type 309 (passive)
Stainless Type 302 (active)	Stainless Type 310 (passive)
Stainless Type 309 (active)	Stainless Type 316 (passive)
Stainless Type 310 (active)	Silver
Stainless Type 316 (active)	Graphite
Lead-tin solder	Gold
Lead	Platinum
Tin	**CATHODIC END**
Nickel (active)	**More noble**



Test parts of dairy equipment indicate that Types 201, 202 stainless steel can be used alternately with Types 301, 302 for noncontact surfaces. The composition used contained 17 Cr, 4 Ni, 10 Mn.

Design Considerations

The 37 standard AISI types of stainless steel plus several proprietary grades give the designer an exceedingly wide choice of materials to meet nearly any corrosive situation. But the designer's duty obviously does not rest with the choice of material. Within the structure he must incorporate elements of design that will enable stainless steel to give its best performance.

In other words, stainless steel, like any other material, will not live up to expectations if it is

abused in any of the three important levels: the design level, the fabricating level, or the operating level. It is the designer's duty to specify proper conditions for each.

Dissimilar Metals: As with any dissimilar metal coupling, care should be taken when combining another metal with stainless steel. Since the passive stainless steels are grouped very low in the galvanic series, Table 1, most common structural metals are more or less anodic to them.

If the area of the anodic metal is considerably smaller than the area of the stainless steel, the effect will be more pronounced. Note, however, that the anodic metal degrades rather than the stainless. Thus, for example, fasteners of ordinary steel should not be used on stainless steel, since the fastener will corrode severely.

On the other hand, highly anodic metals, such as magnesium are sometimes used for cathodic protection of stainless. The anodic metal is sacrificed and the stainless protected by the resulting cathodic current.

If the area of the anodic metal is larger than the stainless steel area, the coupling is usually satisfactory. An example of this is the use of stainless steel fasteners or weld beads on carbon steel. The increased corrosion of the carbon steel is of relatively little importance, since it is dissipated over a large area. The corrosion resistance of the stainless steel is enhanced in this combination, because the stainless is rendered more cathodic in the process. However, one caution should be noted. If paint or other protective coating exists on the more anodic material, rapid corrosion might occur to the area under a break in the coating. This situation is equivalent to a small anode coupled to a large cathode.

Crevices and Joints: Since crevice corrosion can occur at metal surfaces in contact and wetted by a corrosive medium, joints and other faying surfaces should receive careful attention. Where crevices or metal-to-metal contact are unavoidable under corrosive circumstances, the use of Type 316 is recommended. If not prohibited by other conditions, painting the faying surfaces with zinc chromate may be desirable.

In general welded joints are preferable to riveted joints. Welded joints can be butted or lapped; the latter should be welded at both ends of the lap. If the joint is riveted, the faying surfaces should be painted. If rolled, crimped or spot welded seams are used, they should be filled with weld or braze metal or solder.

Flanged joints with gaskets are preferably machined, instead of rolled, to insure a close fit at the bearing surfaces. Crevice corrosion is less likely to occur when the corroding medium is unable to penetrate the joint.

Gaskets or packing should be carefully selected. In most instances porous materials can cause severe attack by absorbing the media and building up a high concentration. Rubber has not been successful as a gasketing material nor have packings containing graphite. In general, synthetic products containing nonabsorbent materials, asphaltum, and zinc chromate paints are preferred gasketing or protective materials.

For the same reasons, direct contact of stainless with wood, rubber, fiber or other porous materials which can build up and retain concentrations should be avoided.

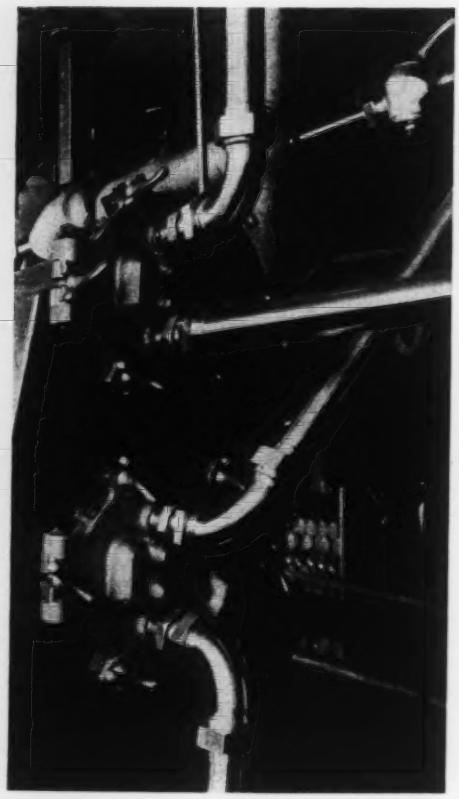
Drainage: Proper drainage at all points is also important. Stiffeners should not be closed at the lower end where moisture can be trapped. Drain plugs should be located at the lowest possible point in a tank and should not project above the tank bottom. Fill crevices in plug base with weld metal and grind smooth.

Care should be taken that crevices and moisture traps do not exist at the support points of a tank or vat. The use of grouting around a base is not recommended. It is preferable to stand equipment on stainless steel legs.

Sharp interior corners, dead angles, and lodging places for deposits should be eliminated. Make smooth corners with large-radius bends where possible. Fillet sharp inside corners with weld metal if necessary.

Finish: In general, the highest possible finish economically feasible is recommended. The higher the finish, the higher the resistance to corrosive attack. Many designers have specified No. 4 sheet finish as having the best combination of corrosion

Designed for easy access and proper cleaning, this manhole cover on a stainless-steel food processing vat is easy to open, yet provides a positive seal. Cover is inserted through elliptical hole, turned to fit, and locked in place by simple clamping device. Gasket, made of nonabsorbent material, is quickly removed and cleaned.



Stainless steel head and piping designed for easy removal and cleaning in food processing equipment.

resistance and economy. It is important that all welds are polished to a finish corresponding to the adjacent metal. Corners and other hard-to-polish points should receive as much attention as large flat areas of the equipment.

Stresses: In general, the stainless steels are resistant to stress corrosion cracking or corrosion fatigue, when the equipment is properly designed and fabricated. Certain media, mainly those containing halogen ions, may induce these attacks. Therefore caution should be used under these conditions. The design should be analyzed for members under tensile stress, either from externally applied loads or internal stresses from fabrication or heat treating. Possible sources of pitting from crevices should be eliminated, especially lapped joints and under rivet and bolt heads. A grade of stainless should be selected commensurate with the operating conditions. Then stress levels should be kept as far below the yield strength as is economically feasible.

Gage: It is unnecessary to specify higher gages in stainless steel than are needed to maintain proper stress levels. An old design habit with other metals is to add a certain amount of material to allow for corrosion and scaling. Since there are grades of stainless which will resist a wide range of corrosive attack, extra thickness is unnecessary when the proper material selection has been made.

Fabricating to Minimize Corrosion

Joining: Under corrosive conditions, welding has been recommended as the preferred method of joining stainless steel. However, when the corrosive situation is mild, such as an atmospheric environment, mechanical means of joining stainless are often used. It is important, however, to use stainless steel screws, bolts, and rivets when fabricating these metals. If the corrosive medium is strong enough, and fasteners of another material are used, a galvanic cell may be set up to the detriment of the fastener. Even under mild conditions, the nonstainless steel will probably corrode, and resulting corrosive products may streak or attack the stainless surface.

Care should be taken that members subjected to corrosive mediums have as few as possible internal stresses caused by fabrication. If necessary, bolts should be torqued within set limits, and riveting carefully controlled. Drilled holes are preferable to punched holes.

Welding: The stainless steels can be welded by all methods applicable to carbon steel except hammer or forge welding. Carbon arc welding is not recommended. Due to the heat in the welding process, changes affecting the physical or corrosion resistant properties of the steels can occur. Techniques that minimize heating of large areas of the work should be used.

The austenitic grades are highly recommended for welding. Welds made with the austenitics are naturally tough and ductile and can have the same corrosion resistance as the base metal. If the welded material is to withstand severe corrosive attack, anneal after welding, use a low-carbon modification such as 304L or 316L, or use a stabilized type such as 321 or 347.

The ferritic stainless steels are not as weldable as the austenitics. But they can be welded by any commercial method except hammer or forge welding. If properly annealed after welding, they are quite tough, ductile, and have good mechanical qualities, although not equal to those of the austenitics. The 18 per cent chromium types such as 430 are most commonly welded.

The hardenable martensitic types require preheating, postheating, or both—and a full anneal of the finished weldment is desirable. The lower chromium types, such as 410 with 12 per cent chromium, can be softened satisfactorily by annealing.

In the design of welded joints, buttwelds, single or double, are preferred to equalize stresses. Buttwelds are more satisfactory than corner or flange

and lap welds. Annealing, as mentioned, is always recommended wherever possible. It is essential with the martensitic grades.

Heat Treatment: The austenitic stainless steels have their greatest corrosion resistance in the fully annealed condition. Therefore annealing is especially recommended when higher carbon or unstabilized austenitic stainless steel parts have been subjected to welding or cold working. When annealing is impractical, the low-carbon or the stabilized grades should be used. This has been discussed in previous paragraphs. Standard annealing practices, including thorough cleaning before treatment, proper temperature range for the particular type, noncarburizing furnace environment, and rapid cooling, should be adhered to.

Stress relieving of austenitic stainless steels, or heat treatment short of full anneal is not recommended where maximum resistance to corrosion is desired. Under certain circumstances, however, stress relieving is useful when a full anneal is impractical. It is important to remember that heating in the range of 800 to 1600 F will produce carbides in the unstabilized grades. Consequently these types are usually stress relieved in the range of 500 to 800 F for a length of time. The stabilized grades are stress relieved between 1500 and 1600 F to remove fabrication stresses.

The ferritic grades are annealed at moderate temperatures, usually under 1550 F, and cooled rapidly. Light sections should be air-cooled; heavier sections may be either air or water-cooled.

The martensitic grades, as previously mentioned, have their best corrosion resistance in the hardened condition. Procedures to obtain this condition of hardness and corrosion resistance include heating to temperatures in the range of 1800 to 1900 F, followed by quenching. Stress relieving after hardening is a must. The best range of stress relieving temperatures to obtain the most corrosion resistance is between 450 and 700 F. Tempering above that range tends to reduce resistance to corrosive attack, especially in the higher carbon martensitics, such as Types 420, 440A, 440B, and 440C.

Passivation: When a stainless steel product is to be subjected to corrosive media, the designer may find it useful to specify immersing or swabbing with nitric acid—often called passivation. The extent to which this treatment improves the protective oxide film is debatable, for exposure to oxygen or air is sufficient to make these steels passive. However, passivation accomplishes a highly desirable end, namely, cleaning the surface of metal picked up during fabrication. Foreign bodies such as iron particles, imbedded in the surface will often become nuclei of pits or sources of stains.

Anticipating Corrosion during Operation

Certain conditions occurring during operation may affect the corrosion resistance of the equipment. Some of these conditions can be eliminated in the original design; others must be eliminated through proper instructions to the user. The following are some of the points that the designer should watch.

1. Avoid a concentration of corrodents, especially the halogen ions. Watch for stages in the process where accidental variations may occur in concentrations. Gravity, evaporation, condensation, temperature, or other forces may be the cause. Sufficient agitation of solutions helps to cure this.

2. Insure uniform oxygen or oxidizing solutions. These maintain uniform passivity. Agitate solutions. Avoid pockets of stagnant liquid.

3. Keep oxygen level high or eliminate it entirely. A high level of uniform oxygen concentration promotes passivity; on the other hand, complete elimination of oxygen reduces pitting in salt solutions, since oxygen depolarizes passive-active cells.

4. In general, operate at the lowest temperature possible, since pitting increases with higher temperatures. If the equipment is allowed to overheat accidentally, immediate damage may result. Since stainless has low conductivity, warping can occur. If the equipment is held in the sensitizing range, intergranular corrosion is possible. Abuses such as these can be avoided by the addition of warning devices and proper education of the user.

5. Increase pH factor. Pitting is substantially reduced when the alkalinity of the solution is increased.

6. Add passivators or inhibitors to the solution. Most of the relatively few substances that will corrode stainless steel can be inhibited by the proper addition.

7. Reduce fretting by reducing relative motion. Mating surfaces should be slightly roughened for increased friction. Flanged sections should be tightly bolted to eliminate motion. Lubrication should be used where effective.

8. Watch for spots that may become work hardened in service. While this is unusual and requires severe cold working to produce an effect, these areas can be possible danger spots, for cold worked metals are more vulnerable to pitting.

9. Where fluid is moving, allow some air to enter the system to relieve local low-pressure areas, the cause of cavitation, whenever practical.

10. Proper cleaning and maintenance instructions should accompany equipment. Build-ups or deposits of material should be avoided by frequent and regular cleaning.

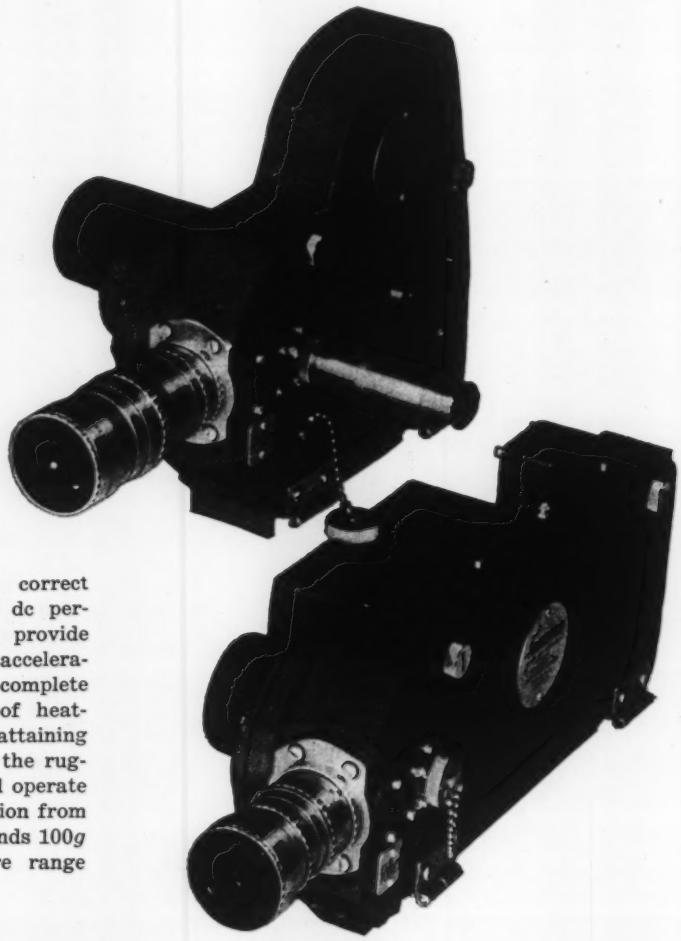
11. Provide ready access to all parts of the equipment for cleaning. Screens, filters, valves, and others should be easy to remove. Openings and access plates should be as numerous as possible. All interior parts should be easily reached.

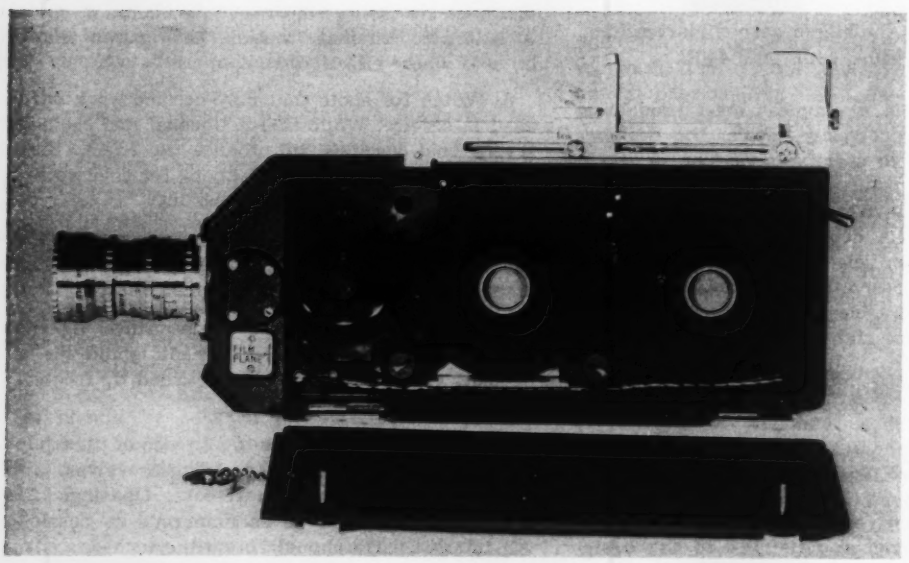
XUM

HIGH-SPEED MOVIE CAMERA

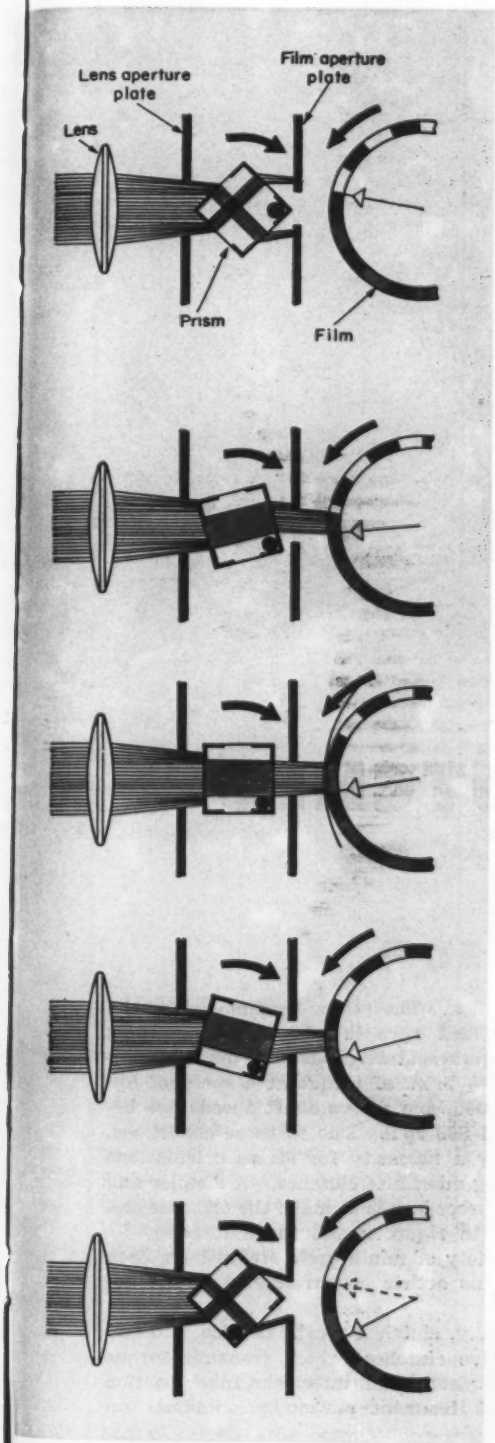
UTILIZATION of a continuously rotating prism rather than a reciprocating shutter, and continuous rather than intermittent film travel, makes exposure of 5000 pictures per second possible in a new motion-analysis camera. Made in both industrial and airborne models by Fairchild Camera and Instrument Corp., the camera is said to have resolution equal to or better than that of intermittent cameras. Steadiness of projected pictures is also said to be improved.

Overall speed range of the camera is from 32 to 5000 pictures per second. This range is covered in four steps. Desired speeds are selected by using the correct drive motor. Drive motors are 28-v dc permanent-magnet type. These motors provide the required light weight and high acceleration rate. Total weight of the camera complete with motor is only 7 lb. Housings of heat-treated cast aluminum alloy help in attaining this low weight and also contribute to the ruggedness of the camera. The camera will operate at 55*g* constant acceleration, 10*g* vibration from 10 to 500 cycles per second and withstands 100*g* shocks with an operating temperature range of −65 to 200 F.



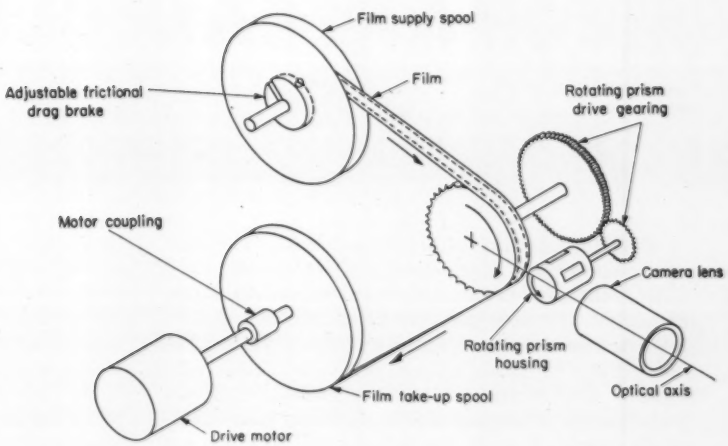


—FILM DOUBLES AS DRIVE BELT

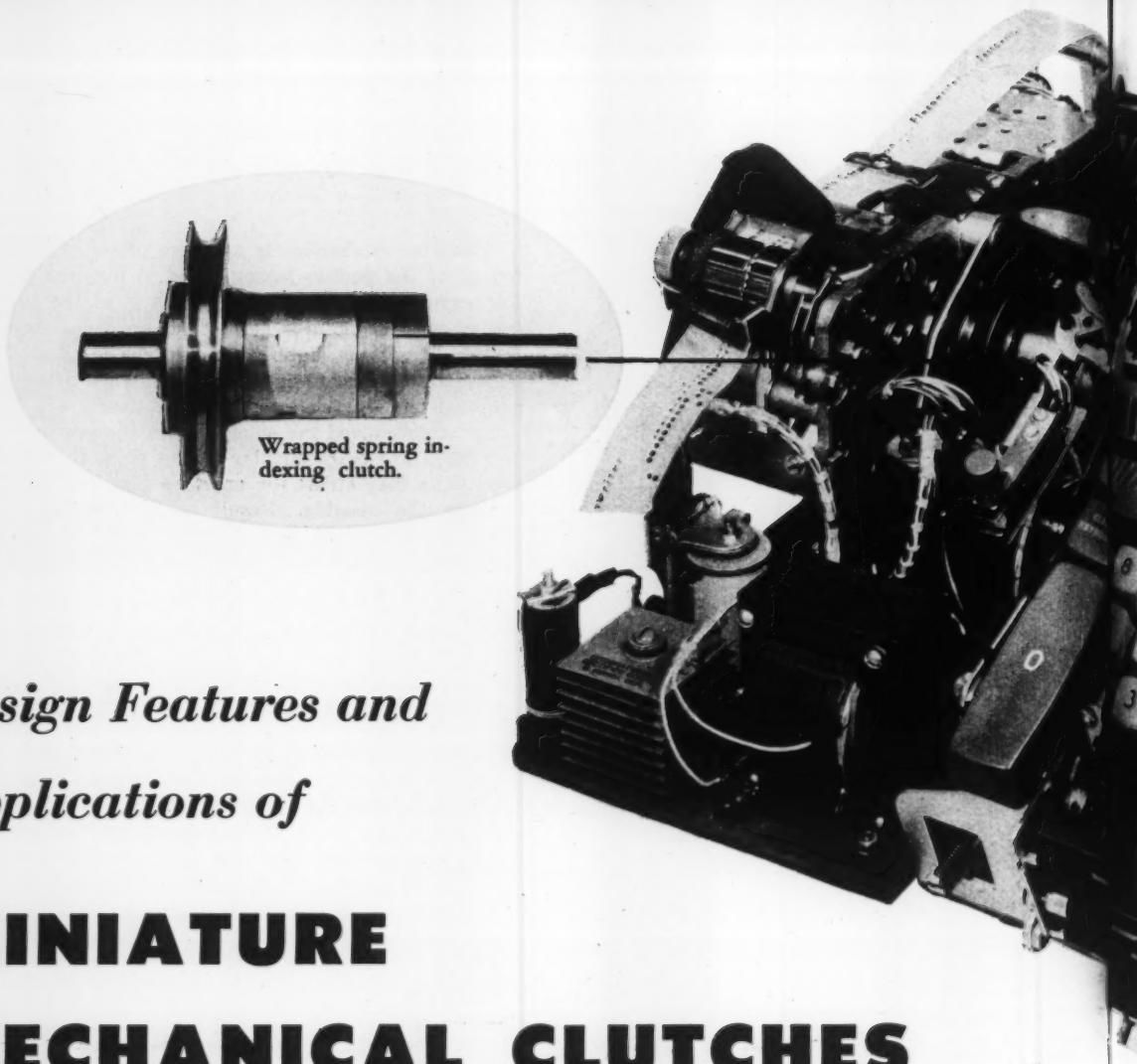


Shutter mechanism is a square prism rotating at one-fourth of the picture taking speed in pictures per second. For example, rotation of the prism is at the rate of 500 rps when 2000 pictures per second are being exposed. As the prism rotates, light from the lens is allowed to pass through the prism to expose the film when prism faces are perpendicular to the light rays, or nearly so. When the prism has revolved far enough from the position in which two faces are perpendicular to the rays, the rays are refracted so they strike the aperture plate rather than pass through the opening. Result of rotation of the square prism through 90 degrees is the same as opening and closing a shutter.

Film drive design is extremely simple by comparison with other high-speed camera drives. The motor is coupled directly to the take-up spool. Film functions as a drive belt for the remainder of the rotating components. The adjustable drag brake on the supply spool serves to eliminate play in the system and excessive over-run when the drive motor power is shut off.



Contemporary Design



Wrapped spring indexing clutch.

Design Features and Applications of

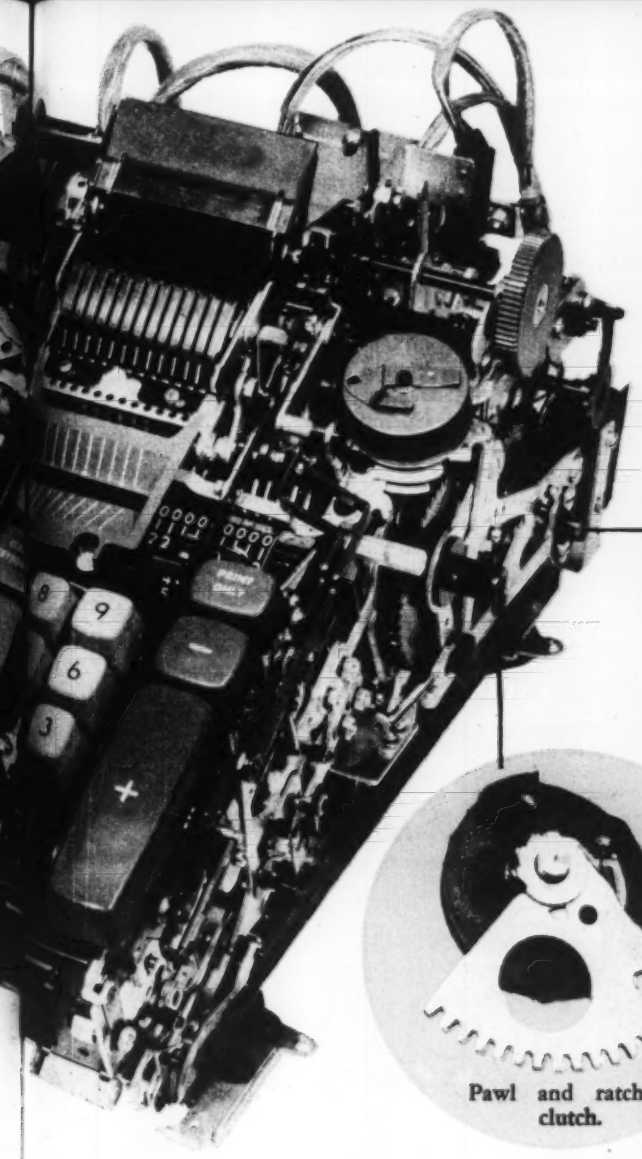
MINIATURE MECHANICAL CLUTCHES

IN THE selection of small mechanical clutches, a number of requirements must be met. Following the present trend to miniaturize machines to facilitate portability, the space available is restricted to the minimum possible. Also, the competitive market makes price and reliability equally important. Production methods and materials must be chosen with exceptional care. Generally, stamped parts and screw machine parts are most suited for economical production. Such operations as milling and grinding should be avoided.

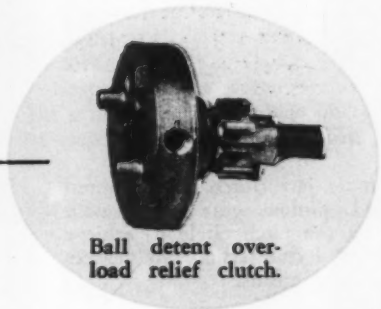
To reduce fatigue of machine operators, manufacturers are constantly striving to minimize pressures required to actuate mechanisms. Frequently these pressures are directly proportional to the force required to operate the clutches in the machines. Therefore, such factors as ease of engagement and disengagement of clutches must be taken into consideration. The power transmitted by the clutches described here is of small magnitude, however. A representative business machine motor delivers 1½ lb-in. of torque at a speed of approximately 3000 rpm. Drive shaft speeds are between 150 and 800 rpm. Due to these conditions, there is rarely a necessity for stress calculations when designing miniature clutches. A simpler and more reliable procedure is to make the clutches and subject them to rigorous endurance tests.

A great variety of miniature clutches have been developed. This article covers several of the important types.

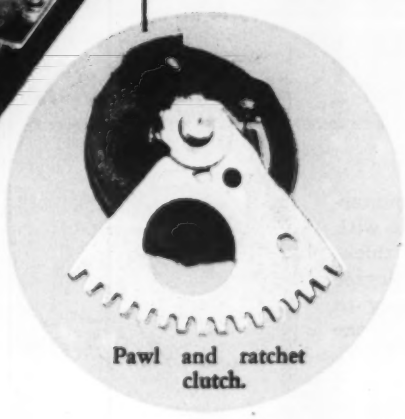
Fundamentally, clutches can be divided into two groups: **positive clutches,** which transmit torque by means of mechanical interlocks, and **friction clutches** which transmit power by frictional resistance.



Typical of small business machines that use several types of miniature mechanical clutches is the Friden Add Punch 10 Key Adding Machine with Automatic Tape Punch.



Ball detent overload relief clutch.



Pawl and ratchet clutch.

Characteristically, miniature mechanical clutches are made of stampings and screw machine parts—often assembled by the manufacturer of the machines that use them — to transmit low power loads at relatively slow speeds. This article presents descriptions, applications and manufacturing considerations for representative types.

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POSITIVE CLUTCHES

Under this classification are many subgroups, the most common of which are: jaw clutches, pawl and ratchet clutches, pawl and splined clutches, planetary transmission clutches, ball-detent reversing clutches, and overload release clutches.

A singular aspect of these clutches in relation to each other is their ability not to slip up to the point of destruction. An exception to this, of course, is the overload release clutch which is designed to transmit torque up to a preadjusted point after which it will release itself.

Jaw clutch

The simplest of all the positive clutches is the jaw clutch, a device which through the direct contact of interlocking lugs or jaws permits one shaft to drive another in either direction. For equivalent torque capacity it is less bulky than any other clutch, and is particularly useful when two shafts must be coupled together in a set angular position to each other, and where the engagement and disengagement occurs at a standstill. Little energy is required to control this clutch for the only force to overcome is the frictional resistance between the gear and the shaft upon which it slides. It is self-locking once engaged and speed is unlimited. Lubrication problems for this type of clutch do not exist; it will run under almost any conditions.

From a practical and economical production standpoint, the clutch shown in Fig. 1 will serve as a good example of a jaw clutch. This multiple-tooth clutch is made from standard gear stock and can be manufactured in screw machines by counterboring on the pitch circle and countersinking the

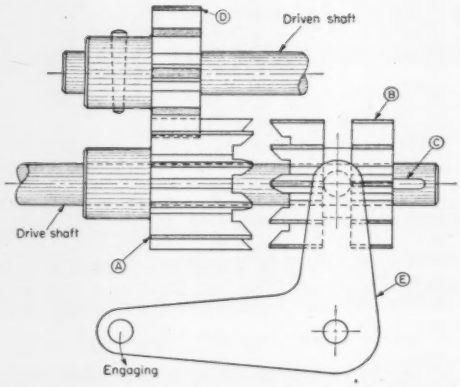


Fig. 1 — Simple jaw clutch manufactured from standard pinion gear stock with counter-bore on the pitch circle to achieve a precise grip and countersunk 90 degrees to provide piloting means.

The drive shaft is provided with a feathered key *C* along which the drive gear *B* can slide axially when controlled by bellcrank *E*. The clutch gear *A*, in mesh with gear *D* on the driven shaft, is free to rotate on the drive shaft. As the two clutch halves are engaged by the motion from bellcrank *E*, motion will be transmitted from the drive shaft through the gears to the driven shaft.

addendum on a 45-degree chamfer. By counterboring on the pitch circle a very precise grip with the mating part will result, since the tooth thickness there equals the tooth space. The 45-degree countersinking on the addendum is necessary to allow piloting means for engagement in case the clutch halves should not be properly aligned.

Theoretically, a line contact engagement of each tooth exists. To maintain a precise grip and to avoid exceeding the moment of safe crushing resistance, the teeth should be carburized and heat treated.

Pawl and ratchet clutch

The pawl and ratchet clutch used quite frequently in business machines is a simple, dependable and versatile type. The main drive clutch used in the Friden fully automatic calculator and in the adding machine will serve as an example, Fig. 2.

This clutch is well suited for economical mass production, since it consists mainly of stamped parts and simple screw machine parts. It has the advantage of conserving space axially, which often is a prime requirement in a crowded machine. The clutch is also extremely versatile and can be adapted for many different control requirements.

By having only one tooth on the driver the clutch can be made to engage in a set relative position to the driver, and by providing additional control arms the driven member can be regulated to index in different positions before a completed cycle. It stops accurately in its indexed position and is locked in both directions by the backstop pawl and the release arm. The force required to energize the clutch is very small. The only resistance for the release arm to overcome is the frictional load created by spring *E* pulling the clutch dog *C* up against the release arm. There is no drag on the driver when disengaged.

A possible disadvantage of this type of clutch is that there is no gradual load acceleration. The pickup is instantaneous, resulting in a shock engagement of the driven members. This shock engagement also will cause some noise which might become objectionable at higher speeds. However, when used in connection with a power source of the magnitude mentioned in the introduction of this article, it has been successfully employed for speeds as high as 800 rpm.

Response speed of the clutch, which is determined by the time counted from the moment the clutch is released until the driver takes hold and rotation begins, is determined by the number of teeth. The more teeth on the driver, the faster will be the response. However, it should be noted that there is always a slight variation in response, de-

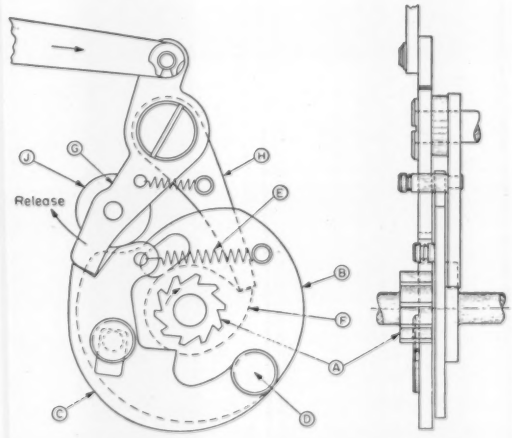


Fig. 2—Pawl and ratchet indexing clutch featuring easy disengagement and two-way lock in home position.

The driver of this clutch consists of a ratchet gear *A* which rotates clockwise. The clutch disk *B* is the driven member and carries the clutch dog *C* which is pivoted at point *D*. The clutch dog is under tension from spring *E*. The backstop cam *F* is secured on the back of the clutch disk.

As the control arm *G* is released from its hold on clutch dog *C*, spring *E* will pull the clutch dog into engagement with the driver *A* and the whole clutch disk assembly rotates clockwise together with the driver.

As the control arm *G* is allowed to return, the roller *J* will follow the contour of clutch disk *B* and at completion of the cycle, the driver will force the dog out of engagement with itself and the backstop pawl *H* will latch on the backstop cam and hold it in this home position.

pending upon the position of the drive tooth relative to the clutch dog at the moment of release.

The clutch can only be driven in one direction and the driven member is free to advance relative to the driver, thereby giving a free-wheeling effect.

In order to withstand the wear from repeated engagings, the driver, clutch dog, release arm and backstop pawl have to be carburized and heat treated.

Lubricating the clutch is no problem and under normal conditions good lubrication at the time of assembly is enough to last during its entire life.

Pawl and splined clutch

This clutch is very closely related to the pawl and ratchet clutch and has practically the same advantages and limitations, Fig. 3. The only important difference is that the splined clutch is a positive indexing clutch which will connect the two shafts rigidly while cycling in the same manner as the claw clutch.

Planetary transmission clutch

The planetary gear clutch is a combination of a transmission and a clutch, Fig. 4. It is a very compact unit which enables considerable speed reduction in limited space. An additional feature is that the output shaft and the input shaft are coaxial.

Centralization of the driven member has to be provided for two reasons: to prevent creeping of the carrier assembly during idling, and to locate the driven member in the same angular position after each completed cycle. It should be noted that there is no locking means on the output shaft in home position as compared to the pawl and ratchet clutch.

Response of the clutch increases in proportion to the number of teeth added on the ring gear. Ease of engagement or disengagement decreases in pro-

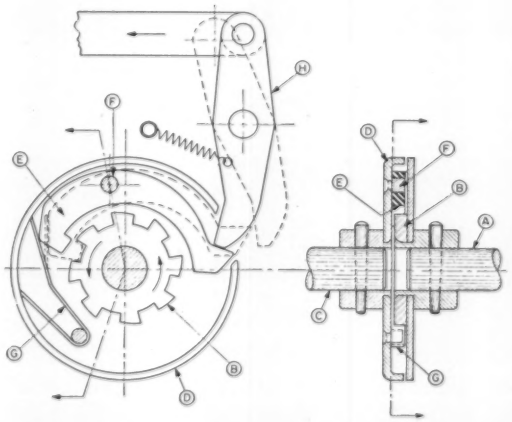


Fig. 3—Pawl and spline indexing clutch providing a positive connection between driver and driven member during torque transmission.

The driver is made up by a shaft *A* and a splined washer *B* rigidly secured to the shaft. The driven member consists of the shaft *C* to which is fastened the clutch housing *D*. The clutch housing contains the clutch dog *E* pivotally mounted on a pin *F* and under tension from spring *G*. Normally the clutch dog *E* is held disengaged.

When activated, control lever *H* is rocked counterclockwise until it is out of the path of the clutch housing rim. This permits clutch dog *E*, from the effect of spring *G*, to engage with the splined driver *B* thereby starting the rotation of clutch housing *D*. Control lever *H* then is allowed to fall back on the clutch housing rim. After rotation continues, the right portion of the clutch dog *E* will connect with control lever *H*, forcing it out of engagement with drive spline *B* and thereby terminating the cycle.

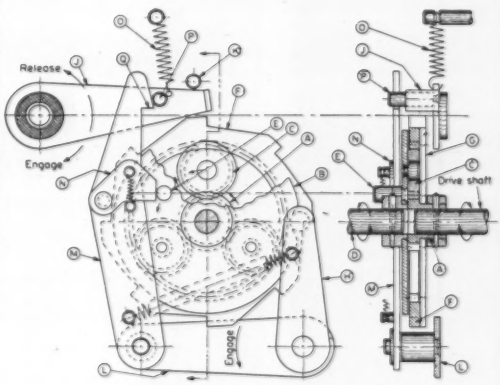


Fig. 4—Planetary gear indexing clutch with gear reduction, single-cycle control mechanism and centralizer.

This clutch has a single-cycle control device and is shown in the terminated cycle position. The driver consists of a sun gear *A* securely fastened to the drive shaft. The driven member is composed of the planet carrier disk *B*, incorporating three pivotally mounted planet gears *C*, which is affixed to the driven shaft *D*. The rim of the carrier disk is cam-shaped to provide means for centralization by the centralizer arm *H*, and it also supports cycle control pin *E*. The clutch controls are made up of ring gear *F* attached to a plate *G* which is rotatably mounted on the drive shaft. Externally mounted is clutch latch *J*, stop pin *K*, centralizer arm *H* and release lever *L* with a clutch pawl *M* pivotally attached to it. As the sun gear on the drive shaft rotates counterclockwise, motion is transmitted through the carrier gear *C* which produces a clockwise rotation of ring gear *F*.

To start the clutch cycling, clutch pawl *M* must be raised by a clockwise motion of release arm *L* until the hooked portion *Q* catches pin *P* on clutch latch *J* which is being held up against the stop pin by tension from spring *O*. Release block *N* will at the same time latch over cycle stop pin *E*. When the clutch pawl *M* thereafter is lowered, release block *N* yields as it hits cycle stop pin *E*. Clutch latch *J* is then moved down in the path of one of the projecting lugs on ring gear *F* thereby stopping its clockwise rotation and permitting the driving force from sun gear *A* to be transmitted with a reduced speed through planet carrier assembly *B* in the corresponding direction of sun gear *A*.

After completion of one revolution, the rotation of the planet carrier will, through cycle stop pin *E* and release block *N*, push the clutch pawl *M* off its hold on clutch latch *J* thereby releasing the ring gear and terminating the cycle.

portion to the torque transmitted through the system.

Noise, which is a limiting factor as far as clutch speed is concerned, can become quite disturbing with excessive idling velocity of the ring gear. To reduce this noise to some extent the clutch latch can be mounted on a resilient bearing.

To eliminate the noise completely and to give the clutch quicker and more uniform response, the controls must include a brakeband arrangement to check the motion of the ring gear. This measure will also reduce the shock load to which the driven members are subjected, but the clutch then comes under the classification of friction clutches.

Considering its usefulness as a transmission and clutch combined, this unit is relatively inexpensive to produce. If manufactured of steel, the moving part has to be heat treated and lubricated periodically. Providing the torque transmitted is low enough to permit it, the gears can be made of nylon whereby some of the noise and the lubrication problems will be eliminated.

Ball and detent reversing clutch

Frequently it is desirable to rotate the output shaft in either direction at a reduced speed while the input member is rotating in one direction. There are many ways of accomplishing this, and the ball and detent clutch, Fig. 5, is one solution to the problem.

Engagement of this clutch in either direction requires very little force, but the energy necessary to disengage the clutch can become quite high depending upon the magnitude of load transmitted and the angle *A*. The angle *A* should, therefore, be made small enough so the resultant force of the torque transmitted through the steel balls is mainly taken up by the ball retainer sleeve and not by the plunger.

Theoretically, there are three positions of the drive disk relative to the ball retainer in which the plunger cannot be engaged. The plunger engaging mechanism has therefore to be furnished with some yieldable means so the plunger can snap into position as soon as a dead spot is passed.

Surface hardness of the drive disk, the ball, the ball retainer and the plunger must be minimum 60 Rockwell C with a case depth of 0.040-in. minimum. The balls are through-hardened and, to facilitate an easy disengagement, a surface finish of 5 to 10 microin. rms on the large plunger diameter is desirable.

The lubrication problems with this clutch are the same as with any other gear train.

This type of clutch has been used with good re-

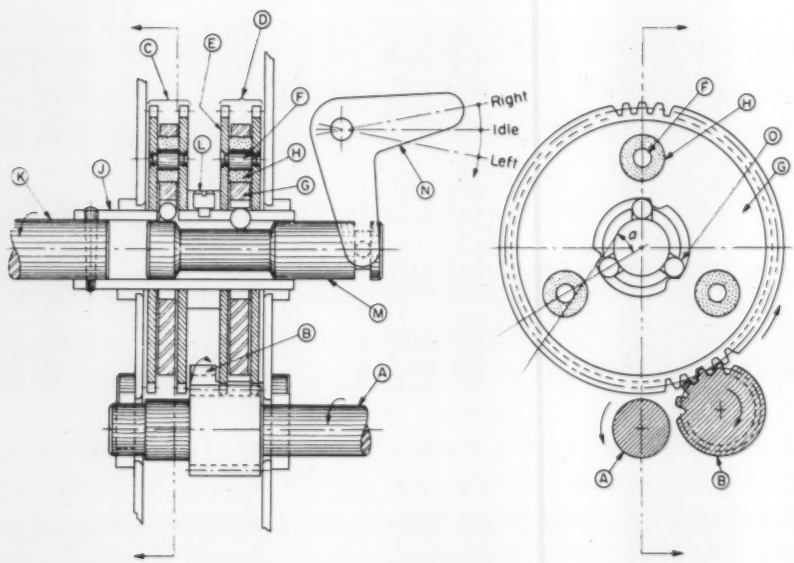


Fig. 5—Ball-detent reversing clutch controlled by a hardened steel plunger and actuated along the same axis as the output shaft.

The clutch mechanism is supported by two bearing plates. The input device is made up of drive gear assembly *A*, idler gear *B* and two similar clutch gear assemblies *C* and *D* which are revolving in opposite directions when idling or while torque is transmitted through the system. Each clutch gear assembly is composed of two flat spur gears *E* held apart by three spacer rivets *F* with the drive disk *G* resiliently mounted in between on three rubber grommets *H*.

The output member consists of ball retainer sleeve *J* secured to the driven shaft *K*, free to rotate between the bearing plates, but held axially by stop collar *L*. The ball retainer also constitutes the shaft for the two clutch gear assemblies *C* and *D*. The control mechanism is made up by plunger *M*, bellcrank *N* and six hardened steel balls *O* embraced by the ball retainer sleeve *J*.

The figure shows the clutch engaged for right-hand drive with the plunger *M* in its extreme right position. With the plunger in this location, three of the steel balls are held out radially to form an effective connection between drive disk *G* and the driven ball retainer sleeve *J*, thereby permitting torque to be transmitted through clutch gear assembly *C*.

To reverse the rotation, plunger *M* must be moved to its extreme left position thereby actuating the three steel balls to the right and in effect connecting clutch gear asembly *D*, which always is rotating in opposite direction to *C*, with the ball retainer sleeve. With the plunger in neutral position, none of the six steel balls are actuated and no movement is transmitted through the system.

It should be noted that the rubber grommets in which the drive disk *G* is mounted serve two purposes. First, they absorb a slight portion of the starting inertia thereby reducing the noise to some extent. Secondly, they will centralize the drive disk while under pressure to equalize the load distribution on the three balls.

sults to reverse the direction of the output shaft at a speed of 800 rpm., utilizing a power source delivering 35 lb-in. of torque at 300 rpm.

Overload release clutch

The overload relief clutches, Fig. 6*a* and *b*, are used in Friden business machines to prevent destructive overloading of the universal electric motor and at the same time to protect the mechanical parts from damage in case of jamming.

A basic requirement in a clutch of this type is that the break-away torque be less than the locked rotor torque at the minimum anticipated voltage supply. Slippage torque must be low enough so that the motor will not exceed its maximum permissible temperature rise at maximum voltage.

When the clutch slips, it creates an irritating noise purposely made to urge the operator to disconnect the current. When the cause of the trouble has been found and corrected the machine is ready for operation without resetting the clutch.

The clutch, Fig. 6a, is inexpensively manufactured by parts made in automatic screw machines and punch presses. It is dependable and has been used to transmit torque values of 30 to 40 oz-in. with a slippage speed of 3000 rpm.

Only slight friction is created by slippage due to the rolling action of the steel balls, thus retaining a low clutch temperature.

Another similar ball detent clutch is shown in Fig. 6*b*. The driver and ball retainer are manufactured from die-cast aluminum. The balls are through-hardened and the splined parts of the driven member are carburized to a depth of 0.020 to 0.030 in., with a surface hardness of 58-64 Rockwell C. The noise level at a slippage speed of 3000 rpm is quite high.

Clutches of this type work only in the event of jamming or misoperation. For this reason they are not required to withstand prolonged slippage.

FRICTION CLUTCHES

A friction clutch is a machine element which transmits motion from the driving member to the driven member by means of friction between the engaging surfaces. These clutches are built in various designs. However, practically all of them can be classified under two groups according to the

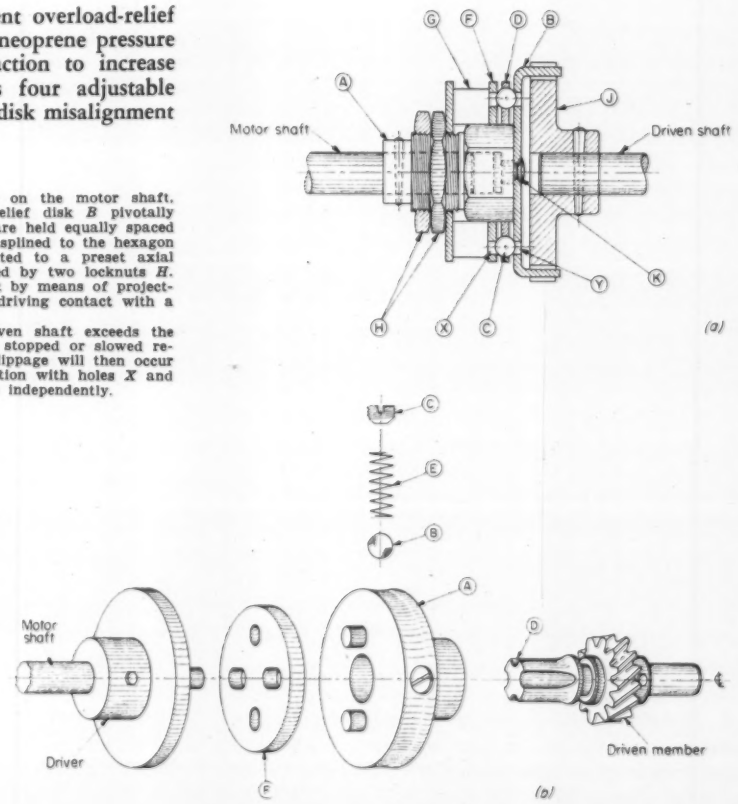
Fig. 6—Representative ball-detent overload-relief clutches. Type *a* has adjustable neoprene pressure ring and rolling ball detent action to increase thermal eficiency. Type *b* has four adjustable spring loaded balls and leather disk misalignment compensator.

The overload relief member, mounted on the motor shaft, is composed of drive nut *A* with a relief disk *B* pivotally placed on the end. Three steel balls *C* are held equally spaced by ball retainer *D*. The drive disk *F* is splined to the hexagon part of the drive nut *A* and is subjected to a preset axial pressure from rubber washer *G*, regulated by two locknuts *H*. Torque is transmitted to the driven shaft by means of projecting lugs on the relief disk which is in driving contact with a splined flange *J*.

When the resistant torque of the driven shaft exceeds the capacity of the motor, the relief disk is stopped or slowed relative to the motion of the drive nut. Slippage will then occur as the steel balls roll out of detent position with holes *X* and *Y*. The drive nut is then free to rotate independently.

Clutch (*b*), disassembled, is composed of ball retainer *A*, employing four spring-loaded balls *B*. Tension on the balls is adjustable by means of screws *C*. The balls are seated in the splined part *D* of the driven member as long as the torque transmitted is below the set limit. When the torque capacity of the clutch is exceeded, four springs *E* are compressed and the balls are forced out of engagement. This allows the ball retainer to rotate freely on the splined part of the driven member.

To compensate for misalignment, power is transmitted by means of a flexible leather disk *F* having four equally spaced slots. One opposite pair of slots engages with two pins on the driver and the other opposite pair matches with two pins on the ball retainer.



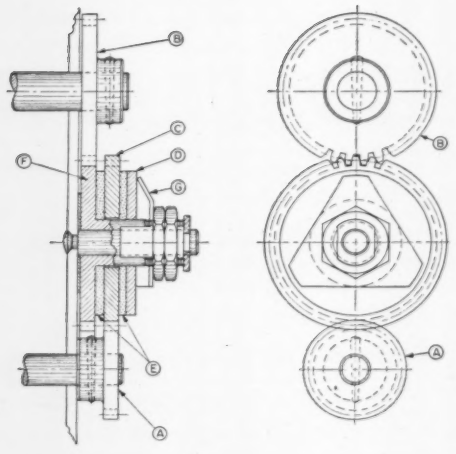


Fig. 7—Single-disk shock-absorbing clutch used as an idler gear, featuring adjustable torque transmitting capacity by means of a spring washer.

The clutch in this case is placed as an idler gear between the driver *A* and the driven member *B*. The rotating motion transferred from driver *A* to clutch gear *C*, is being transmitted to gear hub *F* into the driven member *B* by the frictional resistance set up by pressure from spring washer *G* acting upon pressure disk *D* thereby effectively squeezing clutch gear *C* between the two friction washers *E*.

direction of the acting force: axial clutches, and radial clutches.

In axial clutches the contact pressure is applied in a direction parallel to the axis of rotation. In radial clutches, the contact pressure is applied upon a rim in a radial direction.

To estimate the torque carrying capacity of these clutches the following formulas may be used:

$$T = fPN\left(\frac{r_1 + r_2}{2}\right) \quad (1)$$

where T = torque, lb-in.; f = coefficient of friction; P = pressure between plates, lb; N = number of friction surfaces; r_1 = outside radius of disk, in.; and r_2 = inside radius of disk, in.

In this formula, p, unit pressure between plates, psi, can be substituted for P; and A, combined area of frictional contact, sq in., for N, as follows:

$$T = fpA\left(\frac{r_1 + r_2}{2}\right) \quad (2)$$

One of the chief merits of the clutches mentioned above is that whenever they are engaged to transmit torque there is a period of slip which will cushion shock loads and prevent excessive torsional stresses on the moving parts. This slippage, however, is also a limiting factor due to the heat generated. The heat is proportional to the torque transmitted and the period of slippage.

In heavy machinery the practice is to specify an oversize clutch to safeguard against overheating. Since space in the machines is not highly critical, the size of the mass which absorbs the heat from repeated engagings, and the area of the radiating surface are not severely limited. In miniature clutch design, however, space requirements are of prime importance. Thermal efficiency is the limiting factor and also the biggest reason why friction clutches are less common than positive type clutches in small mechanisms.

Another consideration is that a friction clutch, transmitting a small load and using a constant engaging force, is subjected to variations in torque transmitting capacity due to the presence of dirt and oil. Sensitiveness can be reduced to some extent by specially manufactured friction lining materials of the powdered metal type. In these materials, the difference in the coefficient of friction running lubricated or dry is very slight.

A final precaution on the use of friction clutches in small machines, is that the force required to engage the clutch is relatively high in proportion to its torque capacity. Some form of toggle mechanism is often used to relieve this condition but it has the disadvantage of requiring readjustment as the clutch lining wears.

Axial clutches

Types of axial clutches are the single-disk shock-absorbing clutch and the multiple disk clutch. Both are used most frequently in fractional horsepower sizes.

Single disk shock absorbing clutch: This form of clutch is very commonly used in connection with a positive clutch to dampen engaging shock load, Fig. 7. The shock-absorbing clutch should be placed somewhere between the positive clutch and the power source so as not to disturb the indexing feature.

This type of clutch will be exposed to oil and dirt, since it is an integral part of a gear train which normally should be lubricated periodically. A friction material, which is not affected to any great extent by the presence or absence of oil should be used.

Since the friction surfaces are always under constant pressure from the action of the spring washer, there is practically no chance for dirt to enter and affect the set torque value of the clutch.

To avoid expensive calibrated springs and close tolerances on friction disks and pressure plates, some means of adjusting the plate pressure should be provided.

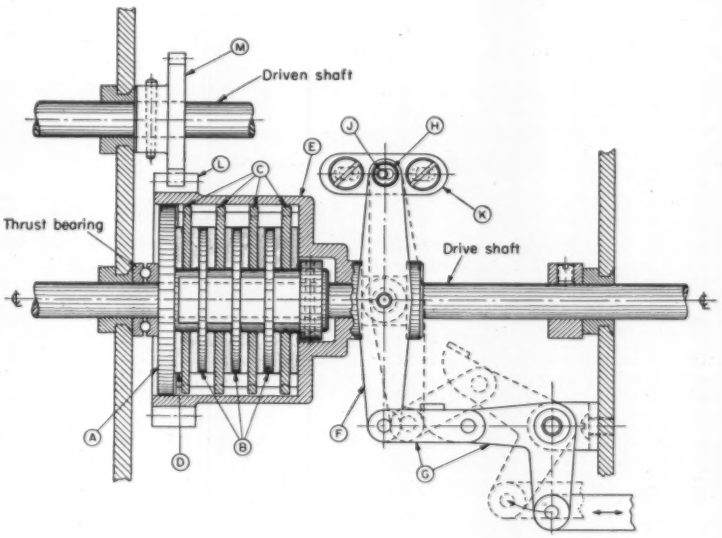
This clutch can also be used as a noiseless overload protection device up to the limit of its thermal efficiency.

Multiple disk clutch: The analysis of a multiple disk clutch, Fig. 8, is similar to that of a simple disk clutch. It should be realized, however, that when axial pressure is introduced into the multiple

disk clutch, a normal pressure is set up equal in magnitude to the axial pressure at every pair of contact surfaces. Therefore, the multiple-disk clutch will transmit N times as much torque as a simple disk clutch which uses the same axial pressure and has the same inner and outer radius of frictional contact surface, Equation 1.

Generally, by increasing the number of pairs of contact surfaces the unit pressure required to transmit a given torque is lowered. This is directly responsible for ease of engagement and long life in clutch plates.

These two reasons, and also the fact that the clutch takes up very little space radially, are con-



The clutch is shown in engaged position. It is essentially composed of one set of rotor disks *B* splined to rotor *A*, which is pinned to the drive shaft, and another set of stator disks *C* splined to the clutch housing *E* and separated from the rotor disks by a set of friction washers *D*.

The engaging mechanism is made up of actuating lever *F* pivotally mounted on pin *J* which is secured to an externally mounted adjustable bracket *K*.

To facilitate a less sensitive adjustment and also a more even engaging pressure the pivot point of actuating lever *F* is rubber mounted. *H*, so it can yield in a direction parallel to the drive shaft.

The normal pressure set up by the toggle mechanism acting on the clutch housing *E* will be effective over the contact surface of alternate rotor disks *A*, stator disk *C* and friction washer *D*, thereby, providing a frictional resistance which will secure all parts of the clutch together and cause it to rotate as one unit with a drive shaft.

Fig. 8—Enclosed multiple-disk clutch with toggle mechanism to facilitate ease of engagement and disengagement.

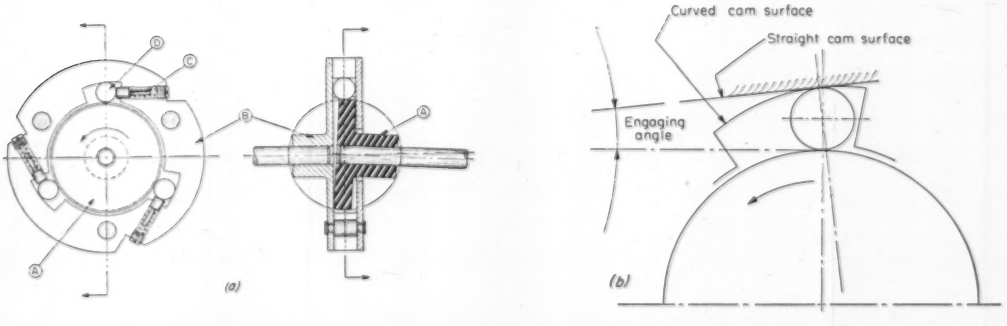


Fig. 9—Free-wheeling clutch, *a*, for light loads, featuring a spherical drive member to compensate for misalignment. Geometric positions, *b*, of curved and straight cam surfaces used in wedge action clutches.

The clutch consists of the input member *A* which will, when rotated in a counterclockwise direction, transmit torque into the driven member *B* by means of static friction created by the wedging action of the three balls *D*.

The springs hold the rollers in continuous contact between cam surfaces; thus, there is no backlash or lost motion, and the operation is positive and quiet.

This clutch is used to transmit extremely small torque values, where instantaneous response and minimum free-wheeling drag is a necessity.

It employs a unique misalignment feature in that the input member is spherical, thereby enabling the clutch to compensate for the type of misalignment where the shafts are in center but out of line.

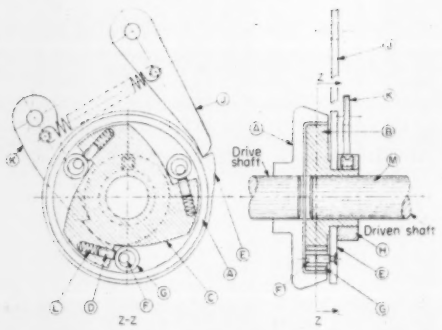


Fig. 10—Cam and roller indexing clutch featuring easy control action, fast and constant response time, and bidirectional lock in home position.

The clutch is composed of the drive housing *A* which is secured to the drive shaft. The driven member fastened to shaft *M* consists of clutch dog *B* employing three curved cam surfaces *C*, and holding three spring-loaded push rods *D*. The control mechanism is made up of indexing disk *E* rotatably mounted on clutch dog *B*, employing three pins *F* used to hold and control the action of the rollers *G*. The illustration shows the clutch in idle position with the drive housing *A* rotating in a counterclockwise direction.

As the index lever *J* is actuated to release its hold on indexing disk *E*, action from the spring-urged push rods *D* moves the rollers into wedging contact between drive housing *A* and driven member *B*. The static frictional resistance created by this action thus transmits torque through the system and makes the clutch rotate as one unit in a counterclockwise direction.

At the end of the cycle, indexing arm *J* catches the projecting lug on index disk *E*. Through the action of the disk pins *F* further rotation of the rollers *G* is prevented. The inertia of the driven member *B* will then, by a continuing counterclockwise rotation, compress the three springs *L*, relieving the wedging action of the rollers and allow the back stop pawl *K* to catch up on stop cam *H*, thereby completing the cycle.

tributing factors for the usage of the multiple disk clutch in small machines.

Since the pressure to operate these clutches is effective over a large number of contacts, ample driving force can be secured even with a good degree of lubrication. The effect of lubrication is to smooth and ease the acceleration.

However, if the oil is caused to carburize or gum up, an undersirable drag on the clutch housing, when in disengaged position, will result. Therefore, a good grade of oil, which will not carburize or otherwise be effected by the running temperature of the clutch, should be chosen.

Radial clutches

Types of radial clutches are the free-wheeling clutch, cam and roller indexing clutch, and wrapped spring indexing clutch.

Free-wheeling clutch: A free-wheeling clutch of radial type is used when it is necessary to transmit rotary motion from two power sources to a common load. Rotation of one power source can be stopped without disturbance to the driving action of the other, or it may be desired to operate two pieces of mechanisms intermittently from one motor.

This type of clutch is also known as an over-running clutch or one-way clutch. It is commonly defined as a form of coupling which transmits full power in one direction of rotation and none in the

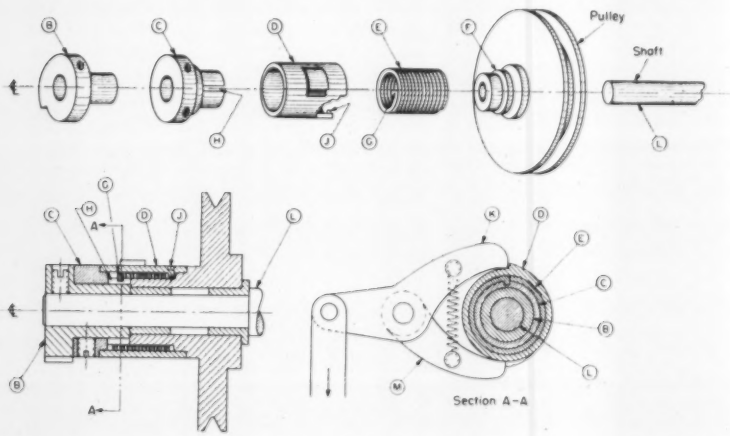


Fig. 11 — Wrapped spring indexing clutch made as an integral part of the drive pulley, featuring ease of control and positive bidirectional lock in home position.

Clutch spring *E* is close wound and made from rectangular wire. The inside diameter is held very accurately, insuring a secure grip on both the pulley hub *F* and clutch collar *C*, onto which the ends of the spring assemble. The left end of spring *E*, assembled to clutch collar *C*, has a right-angle bend *G* that fits into slot *H* in the collar. The right end of spring *E* contacts a protruding point *J* on the inside of sleeve *D*.

The spring assembled will ride over the clutch collar *C* as far as the slot *H* will permit. The opposite end rides the hub *F* of the pulley. Sleeve *D* is assembled over the spring.

With the release arm *K* against the raised surface of clutch sleeve *D*, spring *E* expands enough so that it does not grip hub *F* of the pulley. Therefore, the pulley rotates freely without turning shaft *L*.

As the release arm *K* is operated, sleeve *D* is released. Tension from spring *E*, due to unwound back pressure, is exerted against the protruding point *J* causing sleeve *D* to rotate and allowing the spring to grip pulley hub *F*. The pulley's motion rotates the spring and tends to wind it tighter. The turning of the spring is transferred to collar *C* which rotates backstop cam *B* secured to the shaft.

The spring motion also causes the rotation of sleeve *D*, due to the end of the spring riding against the protruding point *J* on the sleeve's inner surface. When the release arm *K* is restored, it engages the raised surface on the sleeve is stopped.

Continued rotation of the spring exerts a pressure against the edge of slot *H*, which tends to unwind the spring. This increases the inside spring dimension so that it no longer grips the pulley hub *F*, thus allowing the pulley to run free again. The speed of rotation causes backstop cam *B* to overthrow and lock in position against the backstop pawl *M* so the spring is held in an unwound condition, enlarging the inside diameter until the release arm *K* again is actuated.

other. This is true with the qualification that there is always a small amount of free-wheeling torque present, caused by the friction of the rollers rubbing against the inner race, Fig. 9*a*. This free-wheeling torque is necessary for the appropriate functioning of the clutch as it serves the purpose of constantly keeping the unit ready for re-engagement when the speed of the input member tends to exceed the speed of the driven member.

The engaging angle of a free-wheeling clutch made of steel, Fig. 9*b*, should be held between 3 and 6 degrees. Smaller angles tend to become locked and difficult to disengage while larger ones are not effective. The rule is that the tangent of the engaging angle divided by two has to be less than the coefficient of sliding friction for materials used.

An important fact to consider on designing a free-wheeling type of clutch is the choice of straight-sided or curved cam surface. It should be recognized that as little wear as 0.001-in. can under unfavorable conditions alter the engaging angle as much as 5 degrees on a straight-sided cam, while a curved cam surface can be designed to maintain constant wedge angle. The latter type of cam surface is therefore recommended in cases where the endurance of the clutch is of consequence.

A surface finish on the working parts of 5 to 10 microin. rms is required to minimize wear and free-wheeling drag.

A surface hardness of approximately 60 Rockwell C should be maintained on outer and inner race as well as on the balls. Depending on the load transmitted, the case depth should be anywhere from 0.010 to 0.040-in. The balls are through hardened.

Frequency of lubrication and grade of oil to be chosen is governed by the type of service in which the clutch is used. For instrument service a very light oil of good grade has to be used to reduce free-wheeling drag.

Cam and Roller Indexing Clutch: The cam and roller clutch, Fig. 10, is basically identical in its working principle to the free-wheeling clutch. It can be described as a positive-action clutch which transmits torque by means of static friction created by wedging action of rollers between an outer cylindrical drive race and an inner driven curved cam race. The reason it is preferably named a positive-action clutch is that it has the same characteristic as a pure positive clutch in that it is not capable of absorbing any shock loads at time of engagement.

However, it has one distinct feature not found in any of the purely positive type of clutches in that it has a fast response with no time variation from the moment of release until the moment it takes hold. This is explained by the fact that the clutch can take hold in an infinite number of angular positions relative to the cylindrical drive race.

This clutch is relatively expensive to produce, since it requires a high grade of surface finish and closely held manufacturing tolerances on its working parts. Values given for the free-wheeling clutch apply also to the cam and roller type.

The cam and roller clutch can transmit high torque values relative to its small size without sacrificing clutch response, whereas a positive clutch of the type in Fig. 2 will necessarily have to use a coarser tooth on the drive ratchet with higher torque values, meaning slower and larger variations in clutch response.

From the force of inertia, the clutch overruns its index position slightly, but it rebounds immediately and is held centralized accurately by the action of the three springs tending to rotate the driven member up against the back stop pawl.

Forces required to control the clutch are of a small magnitude.

Wrapped spring indexing clutch: Spring clutches form in themselves a basic group of clutches which hold a very important and unique place in the industry. They are especially noted for long life and almost undiminishing efficiency. Representative types are: overrunning clutches, reversing clutches, bidirectional no-back brakes, and indexing clutches.

The wrapped spring indexing clutch in Fig. 11 serves as a typical example for this group. This device is used in a current business machine to connect and disconnect an adding machine power source and a complementary punch tape unit.

The space and weight per pound-inch of transmitted torque is relatively small, and the force required to control it is very light.

When a spring clutch begins to take hold, there is practically no movement of the clutch spring relative to the surface it is gripping. This accounts for longer clutch life, but makes the clutch action positive, meaning the clutch itself is not capable of cushioning any shock loads.

A wrapped spring indexing clutch is relatively expensive to manufacture. It requires grinding operations of both clutch spring and coacting drums to maintain necessary dimensional tolerances and surface finishes. Accurately held dimensions with proper surface finishing reduces heat build-up and wear during operation and also insures uniform clutch action.

The wire section used in the clutch spring is usually a specially designed chamfer keystone shape, die-drawn, high-carbon, oil-tempered wire. The hardness of this wire, a determining factor in the load carrying capacity of the clutch spring, is normally held between 43 to 48 Rockwell C.

The surface hardness of the coacting drums is customarily held between 53 to 58 Rockwell C, but can be held lower where the clutch does not transmit high torque values.

This clutch has been successfully operated at a speed of 1000 rpm. without excessive noise.

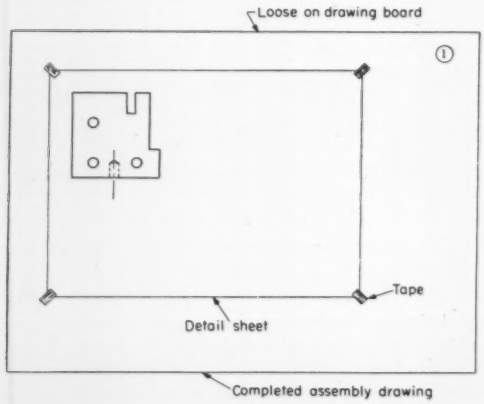
The lubrication problem is practically nonexistent because of the complete enclosure of the moving parts. Proper lubrication at the initial assembly usually is sufficient to last during the entire life of the clutch.

Tips and Techniques

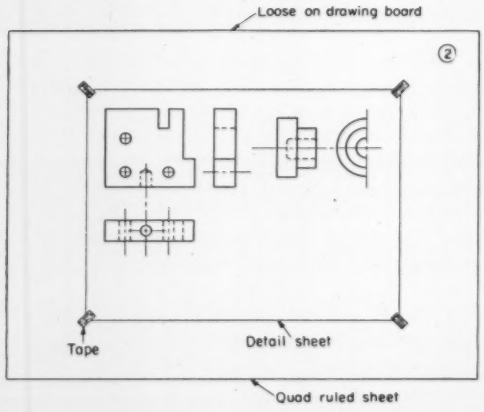
Free-Hand Detailing

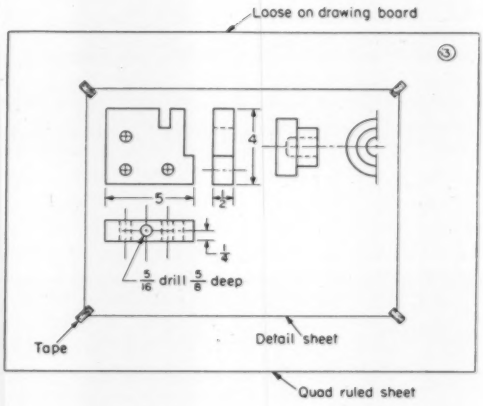
TIME savings of 25 per cent may be realized by employing the method to be described for detailing small tools and mechanisms. To assure an obvious difference in weight of outlines and extension lines, and sharp prints, a medium-weight tracing paper should be used rather than the heavier grades.

Beginning with a conventionally prepared assembly drawing, tape the detail sheet to it but do not fasten the assembly drawing to the drafting board. Then trace the detail free-hand. Use a fairly soft pencil and light pressure when tracing centerlines. Use the same pencil and more pressure for outlines. Use a compass for circles but use no other instruments. Remove and retape the detail sheet and trace all other necessary views in the same manner. Allow space for any additional views which may have to be drawn.



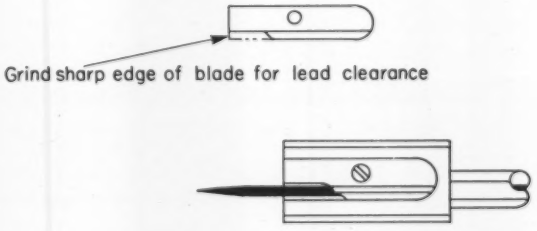
When all the required details shown on the assembly drawing have been traced, remove the detail sheet from the assembly drawing and tape it to a quad-ruled sheet ($\frac{1}{8}$ by $\frac{1}{8}$-in. squares). For convenience do not fasten the quad-ruled sheet to the drawing board. Then, using the quad ruling as a guide, draw in free-hand any other views required, such as top or side views not shown on the assembly drawing. Scale the assembly drawing for sizes if necessary. Extension lines, dimension lines, notes and lettering are then added free-hand but using the quad ruling as a guide to complete the detail sheet.—STANLEY J. BURWELL, *Walker-Turner Div., Kearney & Trecker Corp., Plainfield, N. J.*





Pencil Sharpener

An ordinary pencil sharpener can be converted into a draftsman's pencil sharpener by grinding back the cutting blade as shown to permit the lead to pass through the sharpener.—THEODORE SZUMLA, *Bell Aircraft Corp., Buffalo, N. Y.*



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DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY *(Ninth in a Series)*

Designing for INSTALLATION

By John D. Folley Jr. and James W. Altman
Research Scientists
American Institute for Research
Pittsburgh

An excellent design for maintainability of electronic equipment units can be counteracted almost completely by an installation design that blocks or hinders maintenance technicians. This article shows how best to install electronic equipment units so that individual units and all controls, displays, cables, check points, etc., are quite accessible. Proper location, mounting height, methods of mounting, size, and weight of units are discussed. Good unit - replacement provision, equipment layout and other installation considerations are covered.

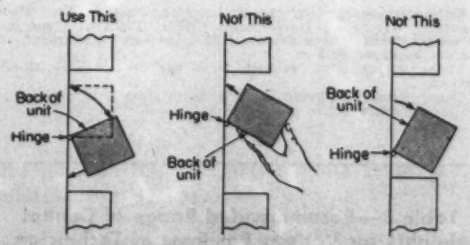


Fig. 1—Install hinge-mounted units to open full distance and remain open without being held.

IN DESIGNING electronic equipment for installation perhaps the basic question the designer should ask is: "Will a technician be able to get to the equipment rapidly and easily as required by his job?"

Maintenance procedures will indicate the portions of the equipment to which access is required for each level of maintenance. The installation must be compatible with these requirements. For example, if trouble-shooting checks must be made in a junction box, the box must be readily accessible. On the other hand, there is no need for the customer technician to have access to the interiors of units that are to be worked on only in a field service shop.

Design features of the equipment and maintenance procedures must be compatible with technical limitations of a given installation. For example, if the space configuration available for installation permits only one face of a unit to be accessible, all controls, displays, cables, check points, etc., must be on that face.

Access to Units: Removal of any particular customer-replaceable unit should require opening only one access panel. Locate units so no other equipment has to be removed to gain access to them. When it is necessary to place a unit behind other equipment, the unit requiring less frequent access should be in the back. Also, units maintained by the same technician should be placed one behind the other because considerable time may be wasted in getting a different technician to remove an obstructive unit.

Units should not be placed in recesses, or behind or under stress members, floor boards, op-

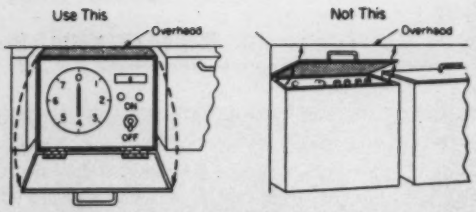


Fig. 2—Units should be installed so that bulkheads, brackets, etc., do not interfere with removal of covers.

Fig. 3—Install electronic equipment with check points, adjustment points, cable-end connectors and labels in open view of and accessibility to the technician.

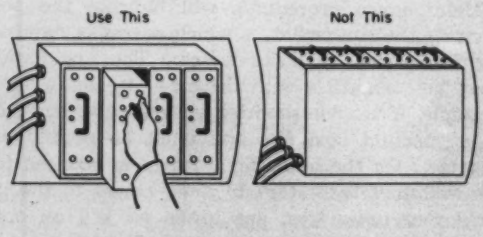


Fig. 4—Design and install major units of electronic equipment to permit removal of subunits without removing the major units.

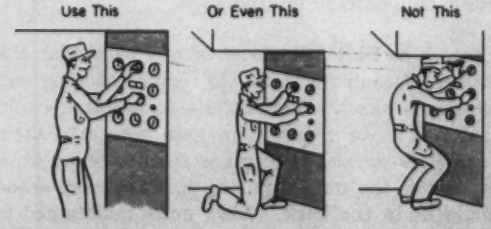


Fig. 5—Install equipment so technician will not have to work in awkward positions.

erators' seats, hoses, pipes or other items which are difficult to remove unless this serves some functional purpose such as protecting the unit or is necessary for some other reason.

Hinge-mounted units for which the customer must have access to the back should be free to open their full distance and remain open without being held, Fig. 1. Bulkheads, brackets, other units, etc., should not interfere with removal of covers of units within which work must be done at the customer level, Fig. 2.

Check points, adjustment points, cable-end con-

Table 1—Male Body Dimensions* for Various Work Positions

Work Position	Body Dimension (in.)
Standing	
Height to top of head	73
Shoulder width	20
Chest thickness	13
Overhead reach	76
Depth of reach	23
Crawling	
Height to top of head with head raised	31
Overall length	59
Prone	
Height to top of head with head raised	17
Overall length, arms extended	96

* Data based on measurements of 40 male subjects and were supplied by the Anthropology Section, Aero Medical Laboratory, Wright Air Development Center. Ages of subjects averaged 24.4 years. Dimensions given should make equipment suitable for 95 per cent of technicians.

Table 2—Weight Lifting Capacities of Technicians

Height of Lift Above Floor (ft)	Mean Weight (lb)	Standard Deviation (lb)	5th Percentile[2] (lb)	95th Percentile[2] (lb)
1	226	47	148	303
2	188	40	122	254
3	114	31	63	165
4	76	19	45	107
5	53	16	27	79
6	46[3]	14[3]	23[3]	69[3]

1. Data were supplied by the Anthropology Section, Aero Medical Laboratory, Wright Air Development Center. Tests were run on 19 male subjects whose ages averaged 21.6 yr, weights averaged 161.2 lb, height averaged 69.5 in.
2. These values were derived from the means and standard deviations.
3. These values are based on nine cases since only nine subjects could properly lift this container to this level.

Table 3—Recommended Range of Control Heights for Various Positions of Technician

Position of Technician	Control Heights* (ft)
Standing on the floor	3 to 5
Kneeling on the floor	2 to 4
Sitting on the floor	1 to 3

*Based on a few measurements made by the authors.

nectors, and labels should face the technician, Fig. 3. They should not be hidden by other units.

Removal of units through the front of the operator's panel is likely to be easier than removal from the back, because more space is usually available at the front. Locate major units so that customer-replaceable subunits can be removed without removing the major units from the installation, Fig. 4.

Steps in Planning an Electronic Equipment Installation

1. Determine what technical limitations are imposed.
   - How much space is available and in what shape?
   - How must the weight be distributed?
   - What will be the physical sizes and weights of the various equipment units?
   - What are the restrictions on cable lengths?
   - What access panels or doors will be available?
2. Determine what maintenance operations the technicians will have to perform on any portion of the equipment *while it is installed*.
   - Which units will the technician need access to?
   - What sides of these units must be accessible?
   - What units need servicing, or are likely to be replaced often?
3. Deduce from Item 2 what the needs are for access to the various units of the equipment.
4. Specify an installation compatible with technical limitations and needs for access.
   - Decisions should be co-ordinated between the installation builder and equipment designer.
5. Request a change in either technical limitations or maintenance procedures if technical limitations force an installation which will make maintenance difficult.

Equipment Height, Space and Weight: Physical characteristics of maintenance personnel must be considered in the designing of electronic equipment installations. The body dimensions for a group of 40 young adult males in various working positions are shown in Table 1. These data can assist designers in estimating the approximate space requirements of maintenance tasks performed in the various positions listed.

In Table 2 are given the maximum weights that 19 young adult males could lift to various heights above the floor. These data can serve as guides to the designer in determining the weights of equipment units to be lifted to various heights. It should be noted that these figures are for simple lifting of a weight of a relatively convenient size and shape, working in the ideal lifting position with the weight close to the body, and with practically unlimited space in which to work. When conditions more closely approximating realistic maintenance conditions are imposed, the weights that can be lifted effectively are much smaller. For example, a preliminary study of the relationship between access size and performance of maintenance-type tasks showed that lifting only 35 lb to a height of 4½ ft may be almost impossible under certain fairly typical conditions. Young adult male subjects had extreme difficulty lifting a 35-lb, 8-in. cube with four short legs through an access 4½ ft above the floor and positioning it onto raised strips 24 in. behind the access panel. Observation of attempts to perform this task sug-

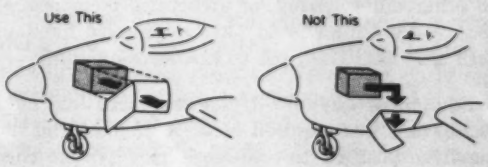


Fig. 6—Electronic equipment should be installed so units are removable along a straight or slightly curved line, if possible.

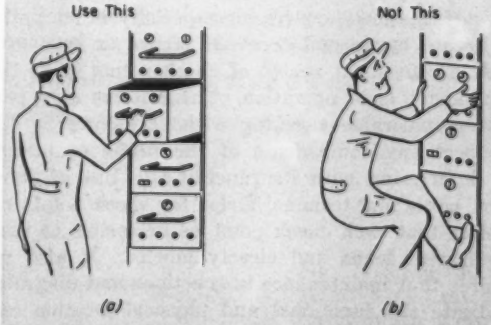


Fig. 7—Position handles and grips to allow easy and comfortable removal of electronic equipment units.

gested that if the cube had contained electronic components, the likelihood of damage through dropping or other rough treatment would have been great. Technicians should not have to reach out for heavy units—those weighing more than about 25 lb.

The position required of the maintenance technician while working on each unit should be studied. What may look like good accessibility from casual observation may require the technician to hold an extremely awkward position. Comfortable and uncomfortable work positions are demonstrated in Fig. 5. The best heights in feet from the floor for adjustment of controls or routine work are suggested in Table 3.

Unit-Replacement Provisions: Units should be removable from the installation along a straight or moderately curved line rather than through an angle as demonstrated in Fig. 6.

Customer-replaceable units should be independently mounted to the housing rather than being attached to each other. In this way, only the unit to be replaced need be moved.

Provision should be made for support of units while they are being removed or installed. Handles and grips should be positioned so they can be held comfortably while the unit is being removed or replaced, Fig. 7*a*. Handles and grips should not be in a position where they are likely to catch on other units, wiring, or structural members, Fig. 7*b*. Heavy units should have a recessed handle on each side near the back to facilitate handling.

Equipment Layout: Units should be laid out so technicians are required to do a minimum of moving from position to position during system checking in the installation.

Junction boxes should be very accessible if customer trouble-shooting procedures require their use as test points. If other test points are available, however, the junction boxes may be relatively inaccessible since they usually require very little maintenance.

Units that require frequent visual inspections, for example, desiccators, should be installed in positions where they can be seen easily without removing panels, covers, or especially other units.

Locate boxes and terminal strips so they provide a convenient source of check points while the equipment is in operation. These items may permit considerable checking without having to disconnect any components of the prime equipment or interfering with its functioning. Use of junction boxes and terminal strips for check points requires that each check point be accessible to test-equipment leads and clearly labeled. It also requires that maintenance instructions and diagrams indicate the functional and physical location and use of these points.

Other Installation Considerations: Provision should be made for easy passage of replacement cables with their attached connectors through walls, bulkheads, etc. There have been instances in which it has been necessary to unsolder 20 or more pins to remove a connector in order to pass the cable through an opening. In other cases, holes have had to be enlarged or new ones drilled.

Units should be located in positions where oil or other fluids, or dirt are not likely to drop on them or on the technician during maintenance.

Power cables should not be routed through switches that personnel in remote locations are likely to switch off or on inadvertently while the equipment is being checked.

BIBLIOGRAPHY

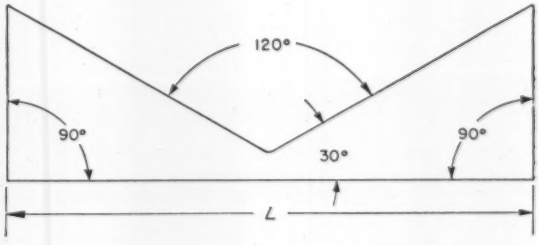
This article is the ninth in a co-ordinated series by John D. Folley Jr. and James W. Altman. Previous articles, and issues of MACHINE DESIGN in which they appeared are:

Designing Electronic Equipment for Maintainability	June 14, 1956
Units, Assemblies and Subassemblies	June 28, 1956
Covers and Cases	July 12, 1956
Wiring, Cables and Connectors	July 26, 1956
Maintenance Accesses	Aug. 9, 1956
Test Points	Sept. 6, 1956
Controls	Sept. 20, 1956
Displays	Oct. 4, 1956

Tips and Techniques

Isometric Triangle

Isometric drawings can be made easier and faster with an isometric triangle such as that shown. The triangle can be easily cut from clear plastic. Length, *L*, may be any convenient value. Time



saved by not having to continually turn the ordinary 30-60 degree triangle is appreciable.—D. J. COLOCCIA, *Wheeler Laboratories Inc., Great Neck, N. Y.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Correction Notice

In the article "Interference-Fit Thread", September 6, 1956, the name of R. L. Jackman, metallurgist, Chrysler Corp. was incorrectly listed as R. L. Jackson on Page 87.

Section Factors for Rectangular and Elliptical Tubes

By B. Saelman,
Design-Weight Engineer
Lockheed Aircraft Corp., Burbank, Calif.

Nomenclature

c = Distance from neutral axis to extreme fiber, in.
D = Outside diameter, in.
dA = Elemental area on section, sq in.
I = Moment of inertia, in.^{4}
I/c = Section modulus, in.^{3}
k = Section factor
M = Ultimate bending moment, in-lb.
m = Applied bending moment, in-lb.
n = Diameter-thickness ratio $= D/t$
Q = First area moment, in.^{3}
R = Outside radius, in.
r = Inside radius, in.
t = Wall thickness, in.
x = Distance of center of gravity of area to neutral axis, in.
y = Distance from neutral axis to any fiber, in.
σ_0 = Minimum stress for trapezoidal distribution, psi
σ_b = Applied bending stress, psi
σ_{bu} = Bending modulus of rupture (allowable stress), psi
σ_m = Maximum stress for trapezoidal stress distribution, psi
σ_{tp} = Proportional limit stress, psi
σ_u = Ultimate material stress, psi

THE elastic theory of bending, considered in classical strength of materials, is based on a linear strain distribution, Fig. 1*a*, and a linear stress distribution across the section, Fig. 1*b*. In the plastic theory of bending, the strain is usually considered linear but the stress is determined in accordance with the stress-strain curve of the material, and is generally nonlinear when the extreme fiber stress exceeds the proportional limit. Cozzone[1] shows that the stress on the section in the plastic range can be conveniently represented by a trapezoidal distribution, Fig. 1*c*, and the modulus of rupture and ultimate bending moment expressed in terms of minimum stress σ_0, maximum stress σ_m, and section factor k.

Section factors were developed in Reference 1 for:

1. I-sections: $1 \leq k \leq 1.5$
2. Solid rectangular sections: $k = 1.5$
3. Channel sections: $1 \leq k \leq 1.5$
4. Round tubular sections: $1.27 \leq k \leq 1.7$
5. Diamond sections: $k = 2.0$
6. L-sections: $1.5 \leq k \leq 2.0$

Reference 2 also contains a very interesting discussion of plastic stress distributions.

[1]References are tabulated at end of article.

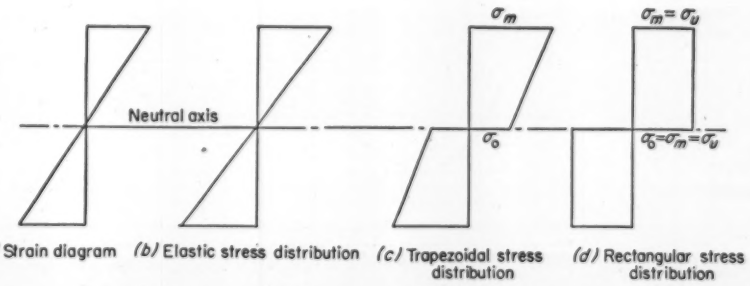


Fig. 1—Strain diagram and three forms of stress distribution.

In this article, section factors are developed for rectangular tubes and elliptical tubes.

From Reference 1, the relationship between ultimate bending moment and ultimate material stress corresponding to a trapezoidal stress distribution is

$$\sigma_b = \frac{Mc}{I} = \sigma_m + (k - 1)\,\sigma_0 \qquad (1)$$

Stress σ_0 is fictitious, and depends on σ_b and on the stress-strain diagram for the material. It increases from 0 for $\sigma_b \leq \sigma_{tp}$ to a maximum value close to σ_u. For very ductile materials, it can be assumed, when $\sigma_b = \sigma_{ba}$, that $\sigma_0 \approx \sigma_m = \sigma_u$, thus resulting in a rectangular stress distribution on the section, Fig. 1*d*. Although a rectangular stress distribution is slightly unconservative, it will usually suffice as a first approximation by designers when ductile materials are employed. Ductile materials are those capable of extensive deformation for a corresponding small increase in stress, such as some of the aluminum alloys. Then, Equation 1 reduces to

$$\sigma_{ba} = \frac{Mc}{I} = k\,\sigma_u \qquad (2)$$

Equation 2 determines an upper limit for σ_b as found from Equation 1. Thus, given applied bending moment, section modulus, section factor, and ultimate allowable material stress, compute

$$\sigma_b = \frac{mc}{I} \qquad (3)$$

Check to see if

$$\sigma_b \leq k\,\sigma_u \qquad (4)$$

If so, the section geometry will, to a first approximation, suffice for design. Equation 2 avoids the use of the fictitious stress, σ_0, which is involved in Equation 1.

It can be shown that the section factor can be expressed for symmetrical sections as

$$k = \frac{2Q}{\frac{I}{c}} = \frac{c\int_0^c y\,dA}{\int_0^c y^2\,dA} \qquad (5)$$

For rectangular tubes, Fig. 2, with respect to bending about axis xx, Equation 5 yields

$$k = \frac{3}{2}\,\frac{1 - \left(1 - \frac{t_c}{c}\right)^2 + 2\frac{t_w}{b}\left(1 - \frac{t_c}{c}\right)^2}{1 - \left(1 - \frac{t_c}{c}\right)^3 + 2\frac{t_w}{b}\left(1 - \frac{t_c}{c}\right)^3} \qquad (6)$$

When $t_c = c$, $k = 3/2$ (solid rectangle, maximum value of k from Equation 6). When $t_w = b/2$, $k = 3/2$ (solid rectangle, maximum value of k from Equation 6). When $t_w = 0$, $k = 1$ (web has negligible bending resistance, minimum value of k from Equation 6). A plot of k versus t_c/c and t_w/b is given for some intermediate values in Fig. 3.

For elliptical tubes, Fig. 4,

$$k_x = \frac{16}{3\pi}\,\frac{a^2 b - (a - t)^2 (b - t)}{ba^3 - (a - t)^3 (b - t)}\,a \qquad (7)$$

Neglecting powers of t higher than the first in the denominator of Equation 7,

$$k_x = \frac{16}{3\pi}\,\frac{2e + 1}{3e + 1} \qquad (8)$$

Section factor for elliptical tubes is plotted in Fig. 5.

Now, when $a = b = R$, Equation 7 reduces to the section factor for round tubes:

$$k = \frac{16}{3\pi}\,\frac{R^3 - r^3}{R^4 - r^4}\,R \qquad (9)$$

In terms of $D/t = n$,

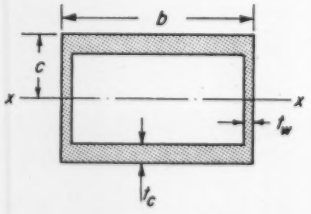


Fig. 2—Above—Nomenclature for rectangular tubes.

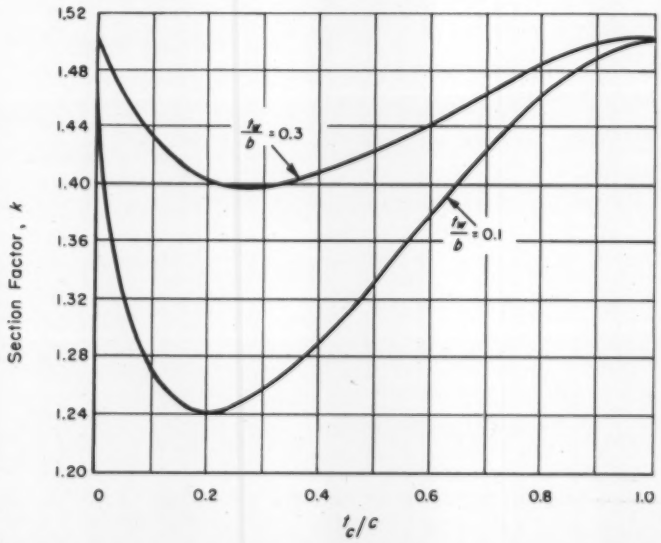


Fig. 3 — Right — Section factor for rectangular tubes.

$$k = \frac{4}{3\pi} \frac{3n^3 - 6n^2 + 4n}{n^3 - 3n^2 + 4n - 2} \qquad (10)$$

Section factor for round tubes is plotted in Fig. 6.

When $r = 0$ (solid round), $k_x = 16/3\pi$. When R/t is large or $R \approx r$, $k_x = 4/\pi$. Similarly,

$$k_y = \frac{16}{3\pi} \frac{b^2a - (b-t)^2(a-t)}{b^3a - (b-t)^3(a-t)} b \qquad (11)$$

When the thickness becomes small compared to the other dimensions, modes of failure other than that due to ultimate plastic moment may become evident—particularly the various modes of instability in both the elastic and plastic ranges. For example, for the case of round tubes there are four definite types of failure, each corresponding to a definite range of D/t values:

$2 \leq D/t \leq 10$	Failure in plastic bending and no local instability.
$10 \leq D/t \leq 20$	Failure in plastic bending with local instability, exhibiting a single transverse fold.
$20 \leq D/t \leq 2000$	Failure by local instability, exhibiting one or more inward diamond-shaped buckles. Plastic range at low values, and locally plastic at higher values of D/t.
$D/t > 2000$	Failure by elastic instability in the form of inward diamond-shaped buckles.

In many cases—particularly those in which the section is composed of some thin elements—instability, stress concentrations, etc., may limit σ_b to a value considerably below σ_{bo}. Although sections of high solidity exhibit the highest bending modulus of rupture, those sections are not the most efficient on a weight basis. Thus the ultimate moment can be expressed as

$$M = 2Q\sigma_u = Ax\sigma_u \qquad (12)$$

Or,

$$A = \frac{M}{\sigma_u x} \qquad (13)$$

It is seen that for sections in which the area center of gravity is a maximum distance from the neutral axis the highest structural efficiency is attained. Representative are I-sections and channels in which the area is concentrated in the flanges.

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2. J. A. Van Den Broek—*Theory of Limit Design*, John Wiley & Sons, New York, 1948.

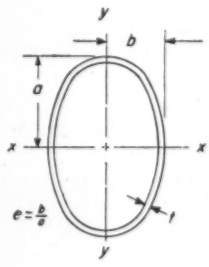
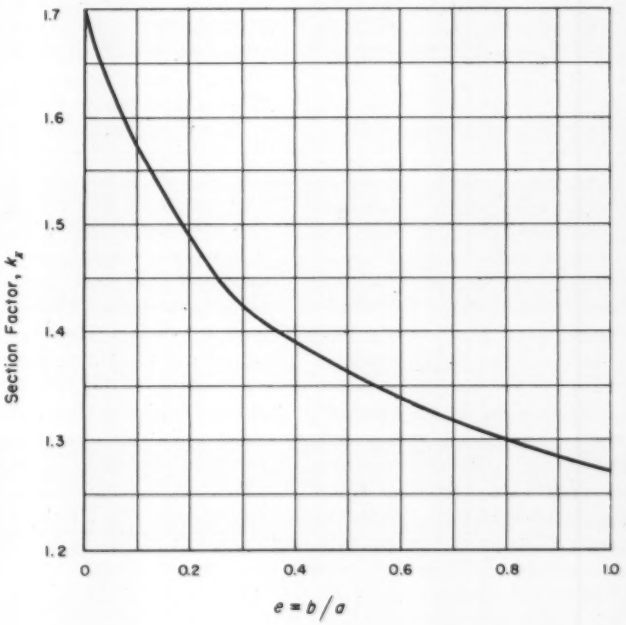


Fig. 4 — Left — Nomenclature for elliptical tubes.

Fig. 5—Right—Section factor (k_x) for thin elliptical tubes.



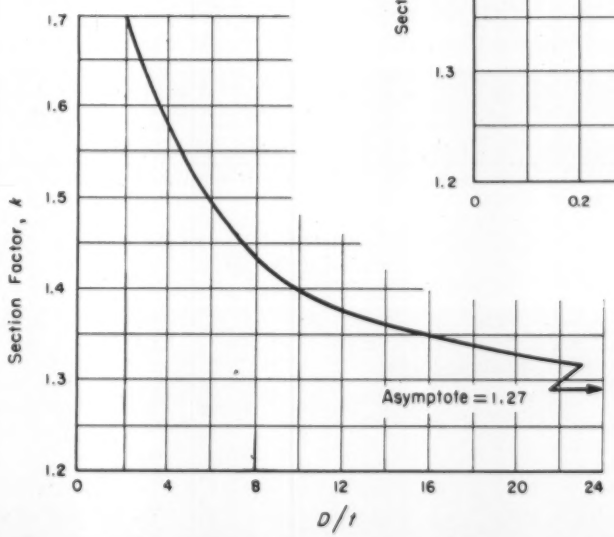


Fig. 6—Left—Section factor for round tubes.

Reluctance Motors for Adjustable-Frequency Drives

THE reluctance motor can be satisfactorily applied to either constant or adjustable-frequency operation. It is ideally suited to applications where many small synchronous motors can be operated from a common-frequency supply; motor speed is set by adjusting the supply-voltage frequency.*

Thousands of these motors have been used because of their inherent ruggedness, simplicity, and low cost. In addition, the reluctance motor is practicable for ratings up to 10 hp. Even larger ratings can be built, but the size and cost may make an excited salient-pole type more economical.

The physical appearance and construction of the reluctance motor is essentially the same as that of a standard squirrel-cage induction motor, except that the reluctance motor is often somewhat larger for a given rating. The appearance of stator, its winding, and the external appearance are the same as that of a squirrel-cage motor. The fundamental difference lies in the rotor design. Salient poles are created on the reluctance-motor rotor by removing some of the iron. Actually, a squirrel-cage rotor can be converted to reluctance operation by a very simple machining operation. If a standard squirrel-cage rotor is milled to give flat sides corresponding to the number of stator poles, the motor will run as a synchronous reluctance motor. The machining of "flats" on the rotor, in effect, forms salient poles at the unmachined surfaces. At these poles, the reluctance of flux to cross the air gap is substantially less than at the flats, where the air gap is much larger. The result is that the magnetic flux crossing the air gap gathers at these poles, tending to lock the rotor poles in synchronism with the stator field. When an external load is applied, the rotor drops back in angular position with respect to the stator field, just as with a conventional synchronous motor. This produces a net pull with a tangential component which is effective in producing torque at the motor shaft, Fig. 1. Of course, this is not a particularly efficient design, and as a result the motor rating is substantially reduced.

Perhaps a comparison of this operation with that of an excited-field, salient-pole motor will be helpful. When direct current is applied to the field winding of a synchronous motor, the reaction of the rotor and stator flux components that produce torque is as shown in Fig. 2. If the dc field is strong enough to supply more than the necessary motor excitation requirements, the motor returns magnetizing current to the power supply at a leading power factor. Under these conditions the torque capacity of the motor is high. However, if the dc field is weakened to the point where it will not supply all of the necessary motor excitation, then additional excitation is drawn from the ac line at a lagging power factor. Under these conditions, the torque capacity of the motor is greatly reduced. If the field is weakened still further, and removed entirely, then all of the excitation must come from the ac line at lagging power factor. Now the motor can carry only a small load torque. The torque thus developed is caused by the "reluctance" torque described previously. Such a reluctance motor will have a relatively small torque rating for a given frame size, and will operate at relatively low power factor.

In practice the motor designer can select certain factors to pro-

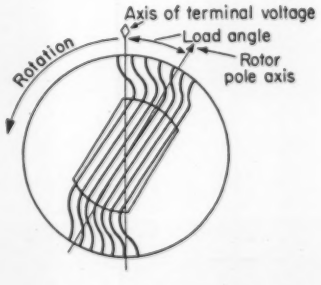


Fig. 1—How the reluctance motor develops torque.

*For additional information on adjustable-frequency drives, see "Adjustable-Frequency AC Drives," by A. T. Bacheler and C. G. Helmick, MACHINE DESIGN, September 20, 1956, Page 145.

DESIGN ABSTRACTS

By C. G. Helmick and A. T. Bacheler

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duce improved performance over that just described. However, reluctance motors seldom operate at power factors exceeding about 60 per cent; with high-inertia loads, and especially when used for adjustable-frequency operation, the motor power factor may go below 40 per cent.

Application Factors: The problems of applying reluctance motors are essentially the same as for ordinary synchronous motors with dc field excitation. Since reluctance torque is much weaker than torque developed with rated dc excitation, the requirements of each particular application must be well known. Some of the most important factors that should be considered are (1) load inertia, (2) pull-in torque, (3) pull-out torque, and (4) motor full-load torque.

Load inertia and pull-in torque are closely associated because both influence the synchronizing operation of the motor. Pull-in torque of a synchronous motor is the maximum constant torque under which the motor will pull its connected load into synchronism, at rated voltage and frequency. The speed to which a motor will bring its load depends on the power required to drive the load; whether the motor can pull the load into step from this speed depends on the inertia of revolving parts. Thus, the pull-in torque cannot be determined without knowing the load inertia as well as load torque. The transition to synchronous operation from squirrel-cage operation is important and deserves close attention. During half of the angular motion of the rotating field, the reluctance torque aids acceleration of the rotor. During the other half of this relative motion, it opposes the acceleration. The load must be accelerated into synchronism with the magnetic field during the torque-aid portion of this angular motion.

When the motor runs close to synchronous speed, even as an induction motor, the relative motion between poles is slower. This affords more time during which the poles are favorably aligned, and facilitates synchronism. Also, the required increment of speed-up to synchronism is smaller, thereby requiring less accelerating torque. By the same reasoning, a large inertia requires more pull-in torque to synchronize within the same time interval. The relationship between pull-in torque and load inertia can be seen from Fig. 3. For example, consider a motor designed for 170 per cent pull-in torque based on its rotor inertia of 0.33 lb-ft^2. If this motor drives a load whose inertia (reflected to the motor shaft) is 2.0 lb-ft^2, the ratio of total inertia to motor inertia is 6.0. From the curve, the reduction factor is 0.41. The net pull-in torque developed by this drive is expressed by the relationship:

$$T_i = KT_o$$

where T_i = pull-in torque with external inertia; K = reduction factor; and T_o = pull-in torque without external inertia. Thus, in this case,

$$T_i = 0.41(170) = 68 \text{ per cent}$$

If the application requires that 100 per cent of full-load torque be pulled into synchronism, then this motor will not be adequate. On the other hand, if the load is a machine that can be started at light load or no-load, then a 68 per cent pull-in torque is suitable.

Pull-out torque is the peakload torque that the synchronous motor can carry without losing synchronism. For steady loads such as many types of pumps, the required pull-out torque will be essentially

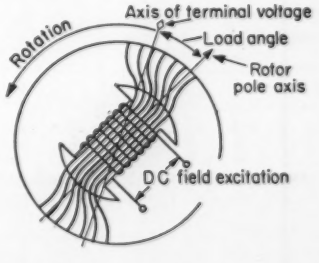


Fig. 2—How conventional synchronous motor develops torque.

full-load torque. Other loads may require high pull-out torque compared to their running torque. The pull-out torque must be sufficiently large to prevent loss of synchronism. In contrast to pull-in torque, load speed is not involved.

The running-torque requirements of the load must also be known. The closer a motor can be applied to pull-out, the better will be the power factor and efficiency. With an ordinary squirrel-cage motor, power factor and efficiency drop off substantially as the motor is unloaded. As shown in Fig. 4, the effect is even more pronounced with reluctance motors.

To summarize, low inertia, low pull-in torque and low pull-out torque all help keep motor size small and performance good. For example, compare two 0.33-hp reluctance motor designs, one for 170 per cent pull-in torque and the other for 200 per cent. The first has a power factor and efficiency of 45 and 72 per cent respectively while the second has 35 and 67 per cent respectively. These figures are based on negligible external load inertia, since in this particular case, a large gear reduction was involved. Without the gear reduction, the reflected load inertia would have been appreciable and a larger motor-frame size would probably have been required to develop sufficient pull-in torque for synchronizing. This would have resulted not only in a larger motor but in a reduced power factor and efficiency as well.

Adjustable-Frequency Factors: The considerations discussed previously are general ones pertaining to normal application of reluctance motors. These principles apply to adjustable or constant-frequency operation. For the adjustable-frequency case, however, two additional points should be examined —torque and thermal capacities.

Torque capacity depends on the motor excitation or flux density. This is easily visualized since a greater flux density at the rotor poles means a stronger pull to keep the rotor turning. If the motor can be be made to operate with the same flux density at all frequencies, then the torque capacity is unchanged. Translated into application factors, this is accomplished by keeping the volts-per-cycle approximately the same for all frequencies. For ranges up to 3 or 4 to 1, this results in keeping the flux density about constant. Thus if a motor is designed for 220 volts at 60 cycles, it should be operated at 330 volts at 90 cycles, or 110 volts at 30 cycles, with proportional voltages for intermediate frequencies as shown in Fig. 5. This can be inherently achieved by maintaining constant dc excitation on the alternator which supplies the adjustable-frequency power.

If a wider range of frequencies is to be employed, especially a range extending to quite low frequencies, special refinements are necessary. Constant volts-per-cycle is no longer adequate to develop constant torque because of the effect of voltage drops, which become appreciable at the lower voltages. Normal voltage drop in motor leads may reduce the motor terminal voltage below the proper value. If frequency and voltage are already low, then a few volts of line drop can be an appreciable percentage of the total. In addition, the high synchronizing current drawn by a reluctance motor will cause an internal voltage drop in the motor, which can be sufficient to affect the pull-in process. This, too, is most pronounced at low frequencies where the applied voltage is low.

To overcome both of these difficulties, the volts-per-cycle ratio can be boosted at the lower frequencies, Fig. 5. A voltage boost of 10 to 15 per cent is common for drives covering a range of 7 to 1 or more. This amount is sufficient to overcome voltage drop and to provide a margin of excess torque

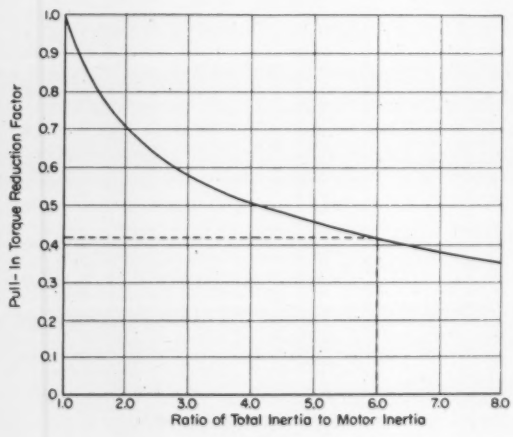


Fig. 3—Relationship between load-inertia effect and reduction in motor pull-in torque.

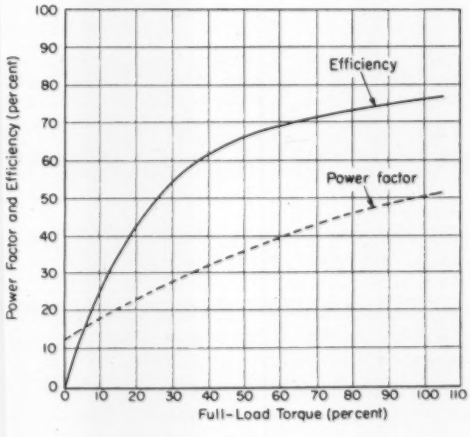


Fig. 4—Variation of power factor and efficiency of a synchronous reluctance motor with load.

HOWELL MOTOR BRIEFS

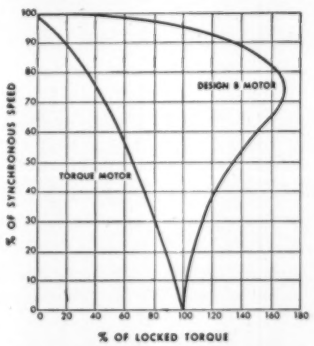
Quick facts for those who apply and specify electric motors

Torque Motors: *They Stall and Hold*

If you want a machine drive to not only apply power but also hold a position or maintain a constant tension, a Howell torque motor may be your solution. Here's a motor that can be stalled, while exerting maximum torque for predetermined intervals, without burning out . . . that can also apply virtually constant torque while operating at a given sub-synchronous speed.

Linear Speed-Torque Curve

The graph below shows this motor's almost linear speed-torque characteristics as compared to a conventional motor's. The secret lies in the design, which produces increased torque while limiting locked rotor current.

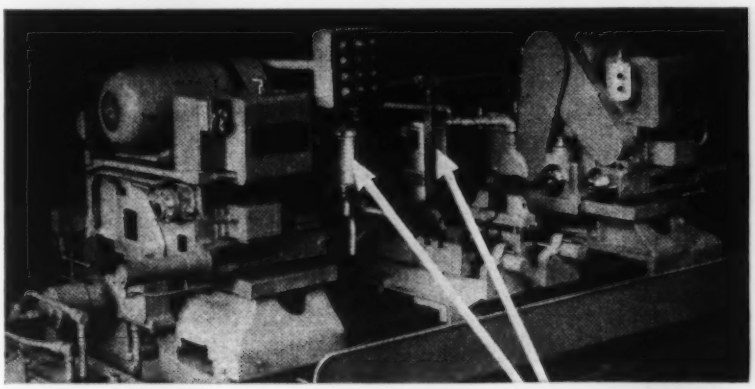


Adaptable to Many Uses

In addition to the clamping, elevator drive and reel tension applications shown at right, Howell torque motors are doing a great many other jobs. Door opening and closing, take-up reeling of film and carbon paper, activating electrical starter contacts and a variety of clutching, chucking and braking operations are among them. They do a quieter, more positive job than many mechanical devices and can often effect important simplifications in machine design.

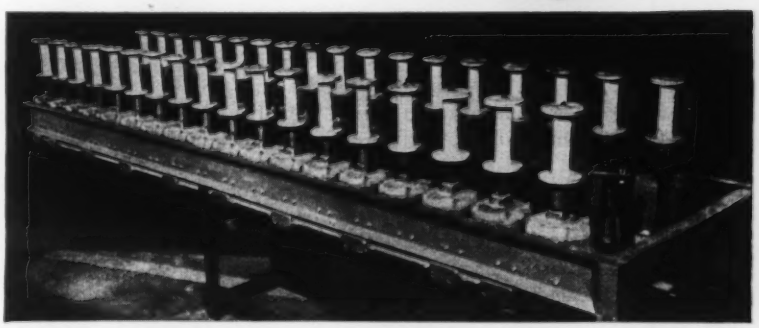
Typical Howell Series 100 Torque Motor

Write us details of *your* requirements. We'll be glad to make suggestions and a quotation.



Two Howell Torque Motors operate clamps for positioning and holding the workpiece on this high-speed, automatic milling and centering machine. Seven Howell motors in all provide power for this precision operation.

A Howell Torque Motor operates the brake and the elevator driving mechanism shown at right. Opening and closing of elevator doors is another typical torque motor application.



A constant, precise tension is maintained on monofilament plastic thread, after extrusion, by the 36 Howell Torque Motors on this winding machine. Multi-speed reeling and winding operations, particularly, are simplified by the use of torque motors in place of geared mechanical devices that are relatively expensive and difficult to keep in adjustment.

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

Circle 575 on page 19

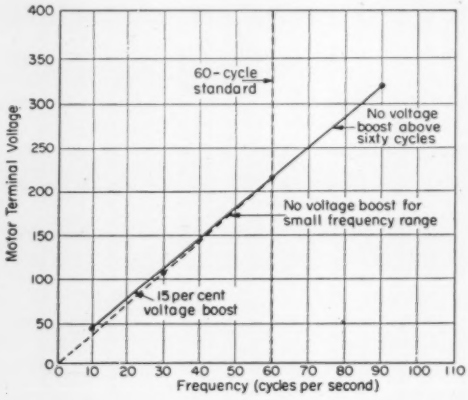

Motor Terminal Voltage
Frequency (cycles per second)
60-cycle standard
No voltage boost above sixty cycles
No voltage boost for small frequency range
15 per cent voltage boost

Fig. 5 — How motor-terminal voltage should vary almost directly with frequency.

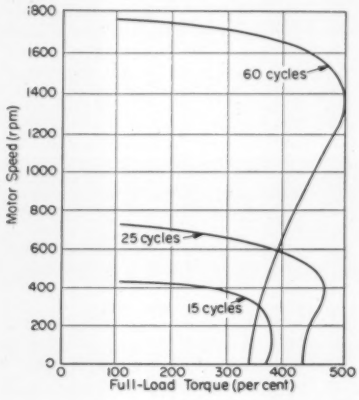


Fig. 6 — Typical speed-torque curves of a synchronous reluctance motor for different operating frequencies.

for synchronizing. However, the extra voltage results in additional exciting current, which in turn reduces power factor and efficiency somewhat. Therefore, judgment must be used to determine a proper compromise. If the load-torque requirements are less at low speeds than at higher speeds, then little or no voltage boost will be required for frequencies down to about 10 cycles or more.

Thermal Considerations: The thermal considerations of adjustable-frequency operation involve two points: (1) the ability of the motor to dissipate heating losses at different speeds, and (2) the magnitude of losses generated at different frequencies. The ability of the motor to dissipate heat depends both on the enclosure and the amount of ventilation available. Ventilation of an open motor falls off rapidly with speed because of the decreased fanning action. A totally-enclosed motor, on the other hand, will dissipate about the same heat at all speeds since there is negligible cooling due to convection. Because of the reduced amount of total heat dissipation for this enclosure, totally-enclosed nonventilated motors are seldom used except where atmospheric conditions make it imperative. Even then, fan-cooled motors are usually recommended for drives operating well above 60 cycles since the cooling action is good at high speeds where the core loss is high. At very high speeds, a fan-cooled motor tends to lose efficiency because of the excessive fan loss that is incurred.

Internal losses generated by the motor include mechanical loss, stator copper loss, and iron loss. The mechanical loss, which includes friction and windage, usually drops off rapidly with decreasing speed. For a constant-load torque, the stator copper loss is approximately constant for all speeds since the motor current is relatively constant. This loss may be increased at low frequencies if substantial volts-per-cycle boost is employed. In adjustable-frequency operation, the iron loss usually falls off rapidly with decreasing frequency.

To determine the thermal capacity of a motor for adjustable-frequency operation, a balance between heating losses and cooling ability must be made. A check of the high and low operating points will usually be sufficient. If the top frequency is much over 90 cycles, core loss may be so great as to present the limiting condition.

For most applications, however, the low-frequency point is the critical one, because motor cooling falls off more rapidly than do the losses. Thus, from the standpoint of both heating and torque considerations, the low-speed condition is a very important case.

Conclusions: A thorough knowledge of the load to be driven, including inertia and torque requirements, can lead to a satisfactory application of reluctance motors to either constant or adjustable-frequency operation, Fig. 6. While conservatism is prudent, it can also be expensive when selecting reluctance motors for an adjustable-frequency drive. Using a motor that is larger than necessary will result in low power factor and efficiency, and will increase the size of the variable-frequency supply alternator. Also, the size of the drive equipment for adjusting alternator speed will be increased.

Wherever possible, load tests of a particular application should be made. Cost of the investigation can be paid for many times by savings in initial cost of the drive equipment.

From "Reluctance Motors for Adjustable-Frequency Drives" in Westinghouse Engineer, *July*, 1956.

HOSE PROBLEMS?

You need this TEFLON® hose

SOLVE your really tough jobs for flexible hose with *Fluoroflex®-T hose assemblies* – the original Teflon hose now proved by over 3 years of demanding service.

With tube made from a patented, special compound of Teflon, the hose is completely inert to the most corrosive chemicals, active oils and fuels, gases, all hydraulic fluids. No swelling, erosion or restriction of tube.

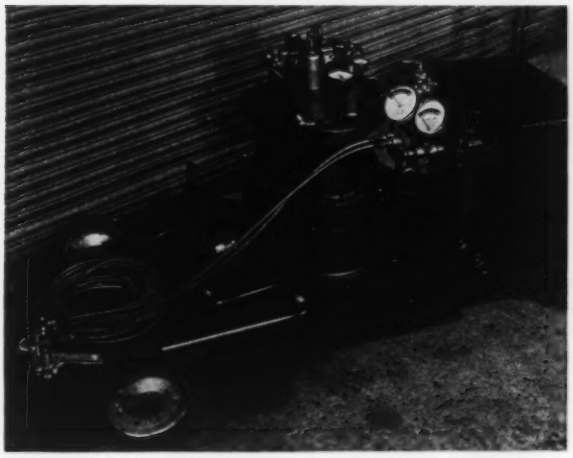
SAE 304 stainless steel braid reinforces for 1000 psi service (higher in some cases) and maintains this strength by its corrosion resistance.

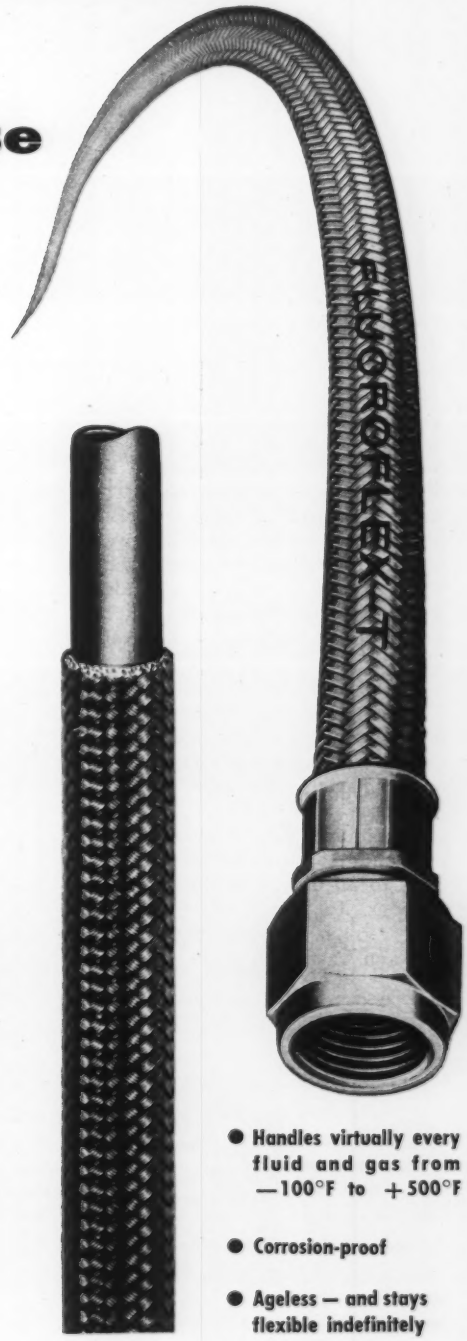
Permanent, swaged fittings give positive protection against leakage and blowoff.

These lightweight, space-saving hose assemblies solve tough problems, increase reliability, cut replacement costs. Made by the originator of Teflon hose – the one company that makes its own Teflon tubing as well as hose assemblies. For more data, write RESISTOFLEX CORPORATION, Roseland, N. J.; Western Plant: Burbank, Calif.

® Teflon is a DuPont trade mark. Fluoroflex is a Resistoflex trade mark.

OVER 2 YEARS' TROUBLE-FREE OPERATION: With this airless spray equipment, industrial finishes and strong solvents are sprayed hot, at 500 to 600 psi. Fluoroflex-T hose has set a service record of over 2 years with no failures.





- Handles virtually every fluid and gas from –100°F to +500°F
- Corrosion-proof
- Ageless – and stays flexible indefinitely

20th year of service to industry

Resistoflex

Circle 576 on page 19

Applying value analysis techniques to *Product Improvement*

By L. D. Miles

Manager, Value Analysis
Manufacturing Services
General Electric Co.
Schenectady, N. Y.

VALUE, surprisingly, is usually not determined by an intensive study but by an extensive one. Value is determined by comparison.

The value of the toaster used in making the morning's toast is not determined by its cost elements but rather by comparison with other means of making toast. The value may be the same if it can be made as conveniently and as well and as interestingly another way. Value is the lowest cost at which a function by any means, can be accomplished effectively and reliably.

Value Analysis: Value analysis is a scientific and sensible evaluation of whatever costs money. It covers parts, assemblies, services, processes, and ideas. Under no circumstances does it ever involve any quality deterioration. It applies to all quantities from one to millions, to any product of any size. Value analysis pushes out far and fast into wide searches and broad comparisons.

How is value analyzed? Here is how it goes. Examine the cover of the control device shown in Fig. 1 with these simple questions:

1. What is it?
2. What does it cost per year?
3. What does it do?
4. What else would do the job?
5. What would that cost?

These are the answers:

1. It is a small molded plastic part.
2. It costs $40,000 a year per million.
3. Although the control device itself is in a semienclosed compartment, it further keeps accidental contaminates out of the control.
4. Extensive study shows that a flat piece of laminated textolite would probably provide the same function.
5. $15,000 for a year's supply.

And so it goes: first, gathering facts; second, facing up to functions; third, recognizing costs; fourth, searching effectively for alternates; last, comparing.

There's more to analyzing value than meets the eye. It sounds simple—but it isn't—because human attitudes are involved. Decisions are based, not upon facts, but upon the partial information—fact and falsity—which people have, and the attitude they have toward this information.

Better value can be achieved through better purchasing, materials, use of specialty products, use of available facilities, processes, and human relations.

Better Purchasing: In one operation, only one product used a capacitor. A telephone call to the purchasing agent at an operation using hundreds of different capacitors paid off with the same capacitor but changed terminals with an $8500 per year saving.

Better Materials: A new item such as filament tape brought packaging possibilities—eliminating $40 from the packaging cost of every hundred washing machines.

Plastic-coated steels can be drawn and require no later finishing, providing very attractive, salable items and necessitating no spray-booth equipment.

Better Use of Specialty Products: Standard cans and boxes can be bought from a catalog instead of making enclosures.

Although we are frequently told that there are no standard springs (each must be designed), there are companies with catalogs of standard springs which can be bought for pennies or dimes, even in low quantities.

Laminated shims are available which can be peeled like onions so that, instead of costly machining, the right thickness is secured in an instant, sometimes saving as much as $10 a machine.

Different forms of raw materials can be used to advantage, such as round disks of aluminum used normally as blanks in impact extrusion presses. In one case the disk was flattened and drilled at a total cost of 13 cents in lieu of a former cost of $1.27 for the part made from sheet.

Rolled spacers can be used where the side is relatively unimportant and the end spacing is important. In one case this meant

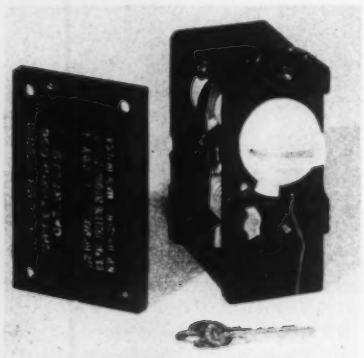
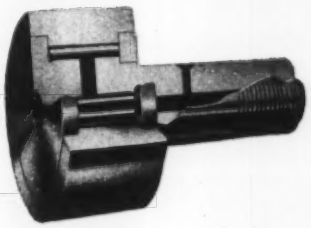


Fig. 1—Control device with cover which was produced at much lower cost after analysis of values.

Fig. 2—Small tubular parts of copper produced by special equipment at a fraction of the cost of those made on general-purpose machines.

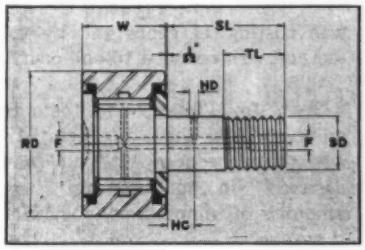
BEARING TIPS by McGill

BEARING BUILT FOR HEAVY-DUTY CAM LOADS



Camrol CF Bearings provide the ultimate in radial capacity, shock resistance and space economy for all cam actioned or guide and support roller applications. An extra heavy outer ring operates on a full complement of small diameter rollers supported by an integral inner race, roller retaining flange and stud. Designed as precision replacement for plain bearing or improvised bolt and bearing units.

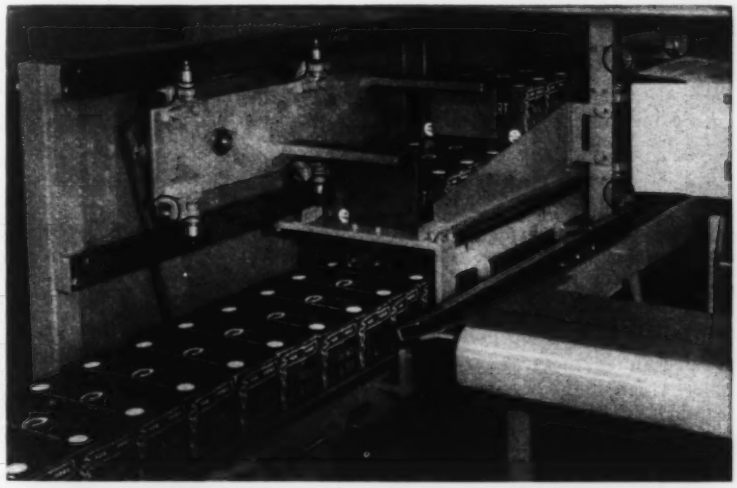
New Sealed Bearing Adds to Versatility of Standard Cam Follower



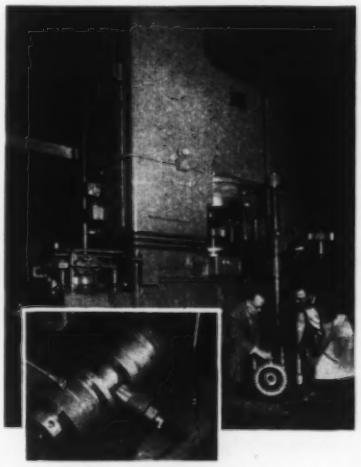
The new SCF series bearing keeps contamination out and lubrication in by means of specially-treated synthetic seals. The SCF bearing is interchangeable dimensionally with standard Camrol bearings.

140 Pages of Bearing Facts

Write for your copy of Catalog No. 52, a revised 140-page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.



CAMROL CF Bearings Cut Power Requirements on J. L. Ferguson Co. Packaging Machines



New Shear-Speed Shapers Achieve Greater Speed and Accuracy Using CAMROL CF Bearings

Michigan Tool Co. uses Camrol CF and CYR bearings in their new machines that produce gears up to 20 inches in diameter and up to 6-inch face widths in only 13 minutes. These bearings, acting as cam followers, accurately control cutting tool feed and relieve tools from the work on return strokes. They insure dependable, precision performance for automatic operation at high production speeds.

Up to 50 Camrol Bearings Used Per Machine

Used as load-carrying cam followers and as guide rollers in PACKOMATIC packaging machinery, McGill Camrol CF bearings have brought several desirable advantages to J. L. Ferguson Company in the eight years this firm has relied on Camrol Bearings.

Exceeding the performance of the roller and pin assembly formerly assembled in the Ferguson plant, the Camrol cam follower bearing has helped improve a variety of cam actuated operations on many of the versatile packaging machines built by Ferguson.

The Camrol CF bearings eliminate wear by reducing friction. This also reduces power requirements for the machines. The CF bearings cost less and are more easily applied than the previous assembly.

For trouble-free operation, up to 50 bearings per machine are now used by this company.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Full Type Roller Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

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XUM

a cost of 3 cents instead of 29 cents.

Terminals, functional and structural parts can be fabricated by specialists from tubing and perform varied functions for moderate cost.

Better Use of Available Facilities: Specialists with special-purpose equipment for fabricating copper tubing provide small tubular parts for a fraction of their cost from general purpose machines. For example, one part, Fig. 2, which had been costing 4 cents with material, labor and overhead, could be had in its finished form, delivered to the plant, for one cent.

A small bracket with tapped holes costing $13 per thousand could be obtained from a specialist who makes small stampings with tapped holes automatically in a labor-free process at a delivered cost of $3 per thousand.

Functional parts made from sheet materials and strip materials can be made instead from wire and wire-formed parts through the skills of specialty suppliers whose engineers are very ingenious in using these engineering materials.

Better Processes: Instead of machining an item such as the pulley shown in Fig. 3 at a cost of 60 cents from steel bar, it is die cast for 23 cents.

Instead of die casting the cover shown in Fig. 4 for $1.02, it is made as a steel stamping for 60 cents.

Instead of an aluminum spacer being machined from sheet for $1.85, it is cast for 50 cents.

Instead of sending bolts and washers, the manufacturer can ship the untrimmed bolt heads which have the flash constituting a washer at no added cost.

Although it sounds most economical to make small terminals from flat copper on a multislide machine, the facts show that terminals can often be provided more economically and of equal strength with less copper from copper tubing by equipment specializing in that field.

Instead of steel rod being bought in two sizes from which a shaft and hub are machined and later assembled with an interference fit, the rod part only is made and used as an insert. Then the hub is cast on, arriving at an equivalent product at half the total cost.

Newer Processes: Instead of buying a hinge from a hardware manufacturer, it might be made by a continuous roll form method, saving 25 per cent of its cost.

Instead of riveting or eyeletting to fasten relatively thin metals together, metal stitching can be used without prepunched holes to literally sew the material together.

Instead of the traditional spot welding, the new cold-welding equipment and process can fasten the parts, with numerous advantages.

Instead of rubber gaskets, Fig. 5, a self-vulcanizing material can be applied which sets up in minutes, such as one application which was costing 11 cents and by this method was reduced to one cent.

Tests for Value: Ten tests for value, which serve to point the way, have been evolved and have assisted in eliminating large amounts of unnecessary cost. Here they are:

1. Does its use contribute value?
2. Is its cost proportionate to its usefulness?
3. Does it need all of its features?
4. Is there anything better for the intended use?
5. Can a usable part be made by a lower-cost method?
6. Can a standard product be found which will be usable?
7. Is it made on proper tooling —considering quantities used?
8. Do material, reasonable labor, overhead and profit total its cost?
9. Will another dependable supplier provide it for less?
10. Is anyone buying it for less?

From a paper entitled "Product Change Improves Manufacturability" presented at the ASTE Annual Meeting in Chicago, March, 1956.

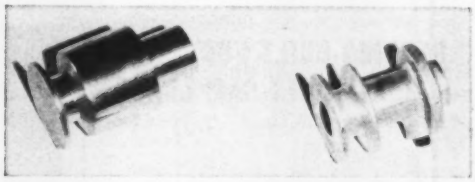


Fig. 3—Pulley as machined, left, cost 60 cents. It can be die cast, right, for 23 cents.

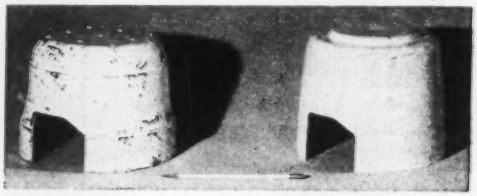


Fig. 4—Cover which can be die cast for $1.02, left, or made as a steel stamping for 60 cents, right.

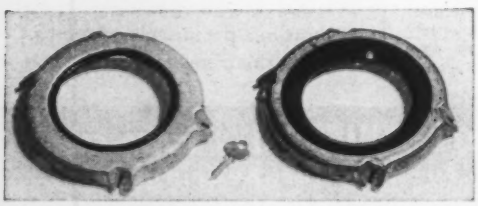
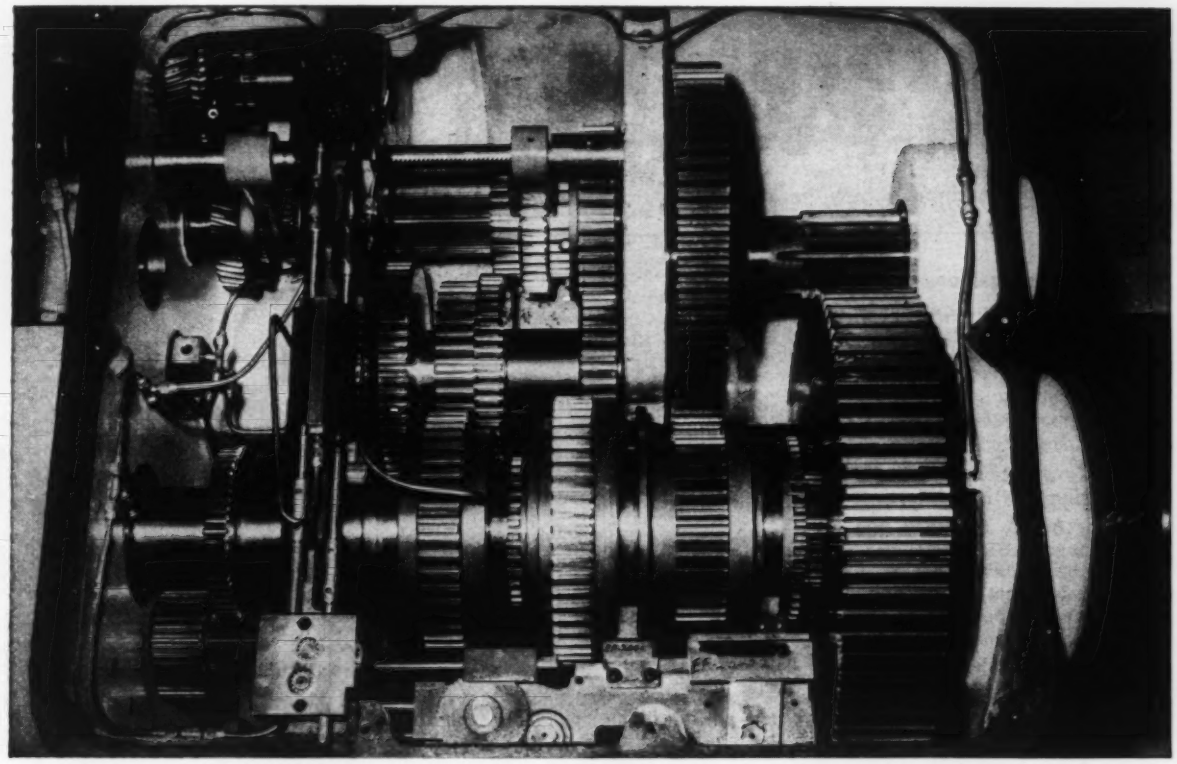


Fig. 5—Rubber gasket, right, which had been purchased for 11 cents. It was replaced by applied, self-vulcanizing material, left, costing 1 cent.



Headstock withstands 100 HP peak loads in new Axelson Lathe designed to operate on 75 hp. E 3310 H nickel-chromium alloy steel gears in this 24-speed unit combine ample strength, toughness and hardness for advanced machine tool design.

Nickel alloy steel gears for new lathe develop core strengths of 150-170,000 psi

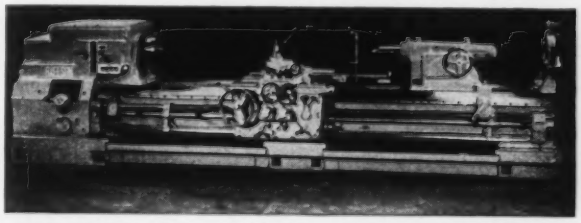
Modern production requirements have induced an ever-increasing demand for machining metals at higher hardness and strength levels, and at the same time for higher speeds and heavier feeds. This has necessitated the building of machine tools of heavier capacities to meet this demand, which in turn has led designers to specify stronger and tougher alloy steels for vital gears and shafting.

The large and massive headstock gears shown above provide a striking example of how Axelson provides exceptionally high case hardness and core strength . . . assuring peak performance of the new 4025 heavy-duty Axelson lathe that operates on 75 horsepower.

By using E 3310 H (3.50% nickel-1.50% chromium) steel, carburized and hardened, Axelson obtains not only tooth surfaces that resist both wear and fatigue, but also core strengths of 150,000 to 170,000 psi.

Perhaps you have made design changes, too, that dictate gears with improved strength, hardness, toughness. Possibly changes in your fabricating methods demand better response to heat-treatment or machining.

You can probably find exactly what you want in one of the many standard grades of nickel alloy steels. So send for a copy of "Modern Trends in Nickel Steel and Cast Iron Gear Materials." Yours for the asking . . . it tells how to meet varied requirements, describes effect of size on properties, and contains other useful information. Write for your copy now.



Designed for high-speed turning of new materials, this new heavy-duty lathe utilizes a carriage of nickel alloy cast iron, along with nickel alloy steel gears and spindles. A development of Axelson Mfg. Co., Los Angeles, Calif.

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

XUM

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Pneumatic Die Cushions

Construction features of model HD pneumatic die cushions with supporting structure for press bed mounting are pointed out in form 119. Cushions are rated for up to 200 psi maximum air pressure. 4 pages. Dayton Rogers Mfg. Co.

Circle 401 on page 19

Self-Locking Nut

Ranging in size from 3/8 to 1 in., line of Structural Rib bolts and self-locking Anco-Nuts is subject of bulletin. Design and application data are given on these fasteners for structural and machine assembly purposes. 4 pages. Automatic Nut Co.

Circle 402 on page 19

Teflon & Rulon Bonding

Literature pertinent to bondability of Teflon and Rulon includes three pieces which describe a surface treatment process that permits these plastics to be firmly bonded to metals, wood, other plastics, cloth and web belts with suitable adhesives. 15 pages total. Dixon Corp.

Circle 403 on page 19

Forgings & Die Sections

Data on smooth hammered forgings, composite die sections and cast-to-shape tool steels are found in illustrated Forging & Casting Div. catalog. Steel finder gives detailed information on various forging and casting steel grades. Dimensional drawings are included. 30 pages. Allegheny Ludlum Steel Corp.

Circle 404 on page 19

Selenium Rectifiers

Features, applications, construction, dimensions, charts and specifications are given for ¾ to 125-kw selenium rectifiers in bulletin GEA-6545. Multiple units up to 500 kw are also covered. 12 pages. General Electric Co.

Circle 405 on page 19

Aircraft Fasteners

Steel aircraft bolts with a minimum tensile strength of 220,000 psi are subject of 12-page illustrated form 2201. Tension-tension fatigue charts and tensile and shear strength charts are included for the Hi Psi EWB-22 bolts. EWN-22 high strength locknuts, a 12-point external wrenching type for use with the bolts, are described in 4-page form 2200. Standard Pressed Steel Co.

Circle 406 on page 19

Brush Holder Springs

Advantages gained from application of Neg'ator constant tension spring as a carbon brush spring are described in illustrated bulletin 310P. Design information is included, as are physical and operational characteristics and applications details and limitations. 20 pages. Hunter Spring Co.

Circle 407 on page 19

Potentiometer

Single - turn, continuous - rotation series 5400 potentiometer for servo or bushing mounting is subject of illustrated data sheet 54-44. It is available with or without ball bearings. Specs, construction, coil characteristics and available modifications are given. 2 pages. Helipot Corp.

Circle 408 on page 19

Repeat Cycle Timer

As many as 12 circuits in sequence can be opened or closed by the Multipulse repeat cycle timer, described in illustrated bulletin 323. Design features, electrical ratings and selection of time range are detailed. 4 pages. Eagle Signal Corp.

Circle 409 on page 19

High Speed Motion Pictures

Recent advances in film sensitivity which have extended the scope of high speed movies for industry are related in illustrated pamphlet "High Speed Motion Pictures at the Service of the Engineer." Five case histories relate how engineering problems were solved. Technical photography and film data are included. 12 pages. Eastman Kodak Co.

Circle 410 on page 19

Photoelectric Controls

Detailed specifications, descriptive data and operational charts on Photoswitch "packaged" photoelectric systems are found in illustrated bulletin PA 561, "Proved Answers to Successful Automation." Line of miniature and subminiature photoelectric receivers and light sources is introduced. 24 pages. Electronics Corp. of America.

Circle 411 on page 19

Speed Reducers

Maximum power output of 0.1-hp at low speed shaft is claimed for Bantam speed reducers described in illustrated bulletin No. 98. Standard units and those with antibacklash feature are covered, each available with over 400 fixed ratios. 4 pages. Metron Instrument Co.

Circle 412 on page 19

Aluminum Extrusions

How aluminum impact extrusions can simplify end products and provide accurate finish is related in illustrated folder. Process causes metal to flow under pressure to provide high strength. Properties, economy factors and comparisons with other methods are given. 4 pages. Impax, Inc.

Circle 413 on page 19

Excitation System

McHenry excitation system for alternator regulation and control provides fast response, positive stability, close regulation and low cost. It is easily installed in existing equipment. System is described and illustrated in bulletin 5.08. 8 pages. Electric Regulator Corp.

Circle 414 on page 19

Ceramic Magnets

Characteristics of Indox ceramic magnet material are reviewed in an issue of Applied Magnetics (Vol. 4, No. 3). Design considerations, manufacturing techniques and applications are covered. 12 pages. Indiana Steel Products Co.

Circle 415 on page 19

Motor Selection

Motor application and selection data for 50 typical applications are included in pocket-size illustrated bulletin GED-2020B. Horsepower, starting ability, shaft speed and voltage terms are explained. 16 pages. General Electric Co.

Circle 416 on page 19

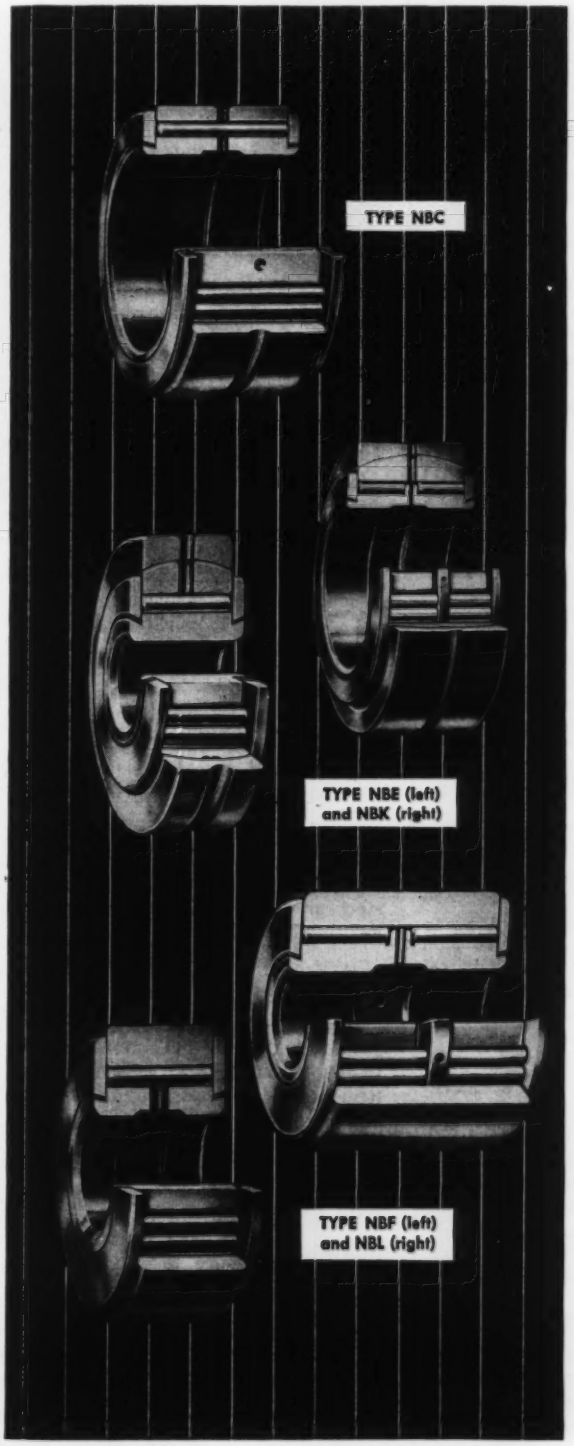
Power Transmission

Technical and selection data, complete specifications and other information on Dodge power transmission machinery are found in illustrated

TORRINGTON

NB SERIES NEEDLE BEARINGS

For Oscillating Motion or Heavy Rolling Loads



Torrington NB Series Needle Bearings employ the same needle roller principle as the famous DC Type Bearing.

They are available in the five types illustrated, all being of nonseparable construction and designed for periodic relubrication. Outer and inner races are of high carbon, chrome steel, hardened and precision ground.

Like the DC Type, the compact design of NB Series Needle Bearings permits saving in size and weight of surrounding parts.

Torrington NB Series Needle Bearings have been used extensively in the aircraft industry and for ordnance work where their extremely high static capacity and anti-friction characteristics enable them to withstand heavy impact loads.

Designs can be modified to meet industrial applications involving rotating motion.

Type NBC—oscillating motion only. Designed specifically for applications in which the OD is supported by a housing and the washers are backed up by clamping surfaces.

Types NBE and NBK—oscillating motion only. Self-aligning. Designed for applications where it is difficult to obtain alignment during assembly or where deflections make a self-aligning bearing desirable.

Types NBF and NBL—heavy rolling loads. Designed for use as rollers under heavy loads at slow speeds.

See our new Needle Bearing Catalog in the 1955 Sweet's Product Design File—or write direct for Catalog No. 55.

THE TORRINGTON COMPANY

Torrington, Conn. South Bend 21, Ind.

District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1865-1955

TORRINGTON BEARINGS

Needle • Spherical Roller • Tapered Roller
Cylindrical Roller • Ball • Needle Rollers

Circle 578 on page 19

catalog D56. Included are bearings, chains, clutches, couplings, Flexidynes, speed reducers and various V-belt drives. 328 pages. Dodge Mfg. Corp.

Circle 417 on page 19

Polyethylene Pipe

Chart of common industrial liquids withstood by Supplex flexible polyethylene pipe and fittings is found in illustrated bulletin CE-57. Applications, standard sizes, installation instruction, technical properties and flow rates are covered. 8 pages. American Hard Rubber Co.

Circle 418 on page 19

Rubber's Properties

"Chemical Resistance" is seventeenth in series telling how physical and chemical properties of elastomers are tested and evaluated. General chemical resistance of noeprene is described in Neoprene Notebook No. 90 and a number of applications are described. 8 pages. E. I. du Pont de Nemours & Co.

Circle 419 on page 19

Steam & Hot Water Devices

Condensed catalog and price list C-63 contains data on these safety devices for steam and hot water: boiler water feeders, low water fuel cutoffs, pump controllers, make-up water feeders, pressure relief and temperature relief valves, combination valves, float switches and valves and flow switches. 8 pages. McDonnell & Miller, Inc.

Circle 420 on page 19

Metal Spinning

"The Story of Metal Spinning" is an illustrated brochure which describes the history of this process and shows graphically exactly how it is done. Principles of economical design are related and case histories are presented. 20 pages. Roland Teiner Co.

Circle 421 on page 19

Industrial Counters

Theory and circuitry underlying substitution of magnetic devices for vacuum tubes in high speed industrial counting equipment is explained in data file 109. It explains the functions and applications of a miniature saturable reactor device called a Ferristor. Beckman Instruments, Inc., Berkeley Div.

Circle 422 on page 19

Precision Balls

Specifications for balls of various sizes, grades and in material ranging from stainless steels to such nonmetallics as ceramic, sapphire and plastic are in this illustrated brochure. Their quality control and 100 per cent inspection for various industrial uses are described. Universal Ball Co.

Circle 423 on page 19

Machinery Mountings

"So You Want to Increase Production!" is title of bulletin K7A which uses case histories to show how profits and production can be increased through use of vibration and noise control machinery mountings. Problem of leveling vs. alignment is discussed. 8 pages. Korfund Co.

Circle 424 on page 19

Small Diameter Tubing

Listed in data memorandum No. 1 are 121 metals and alloys from which standard and special small diameter tubing are produced. They are grouped according to metal, standard or special analysis and whether it is seamless and/or Weldrawn. 3 pages. Superior Tube Co.

Circle 425 on page 19

Analog Computer

The many "firsts" incorporated in 400 series REAC analog computer are detailed in brochure No. 108. The modular building block construction is described, along with component operation. A special section covers direct current amplifiers used in the computer. 16 pages. Reeves Instrument Corp.

Circle 426 on page 19

Guide Pin Bushings

Wear-resistant, low friction guide pin bushings described in bulletin 15.404 are made of premium grade aluminum bronze. Bushings are provided in 26 standard sizes, precision machined with double figure 8 oil grooves. 4 pages. WW Alloys, Inc.

Circle 427 on page 19

Fractional HP Motors

Performance Rated line of industrial quality motors from 1/20 to 1 hp is featured in brochure 1-IPI. Polyphase and capacitor types in open and totally enclosed styles are described along with several mechanical variations. 10 pages. Century Electric Co.

Circle 428 on page 19

Solder Core Contacts

Technical data sheet on solder core contacts for Continental connectors provides specifications covering perfected method of prefilling contacts with a solder alloy of any specified composition. DeJur Amsco Corp., Electronic Sales Div.

Circle 429 on page 19

Temperature Controller

Series 53000 thermistor-actuated temperature controller is an individual unit which plugs into separate power supply chassis. Bulletin MC-133 shows how requisite number of these controllers can be plugged into single power supply chassis. 4 pages. Fenwal Inc.

Circle 430 on page 19

Carbon Steel Balls

"Famous Case Histories from the Files of the Abbott" is title of amusingly written booklet on application of carbon steel bearing balls. Based on series of company advertisments, booklet supplies technical and application data. 8 pages. Abbott Ball Co.

Circle 431 on page 19

Air Cylinders

Twenty-one models of series A nonrotating air cylinders ranging from 1½ through 14 in. bore sizes are covered in catalog 110. Cylinders have floating cushions, brass tubes, removable bronze cartridges containing wiper and rod packing, and cold rolled steel end plates. 12 pages. S-P Mfg. Corp.

Circle 432 on page 19

Forgings & Castings

Catalog on "Forging and Casting Division" gives data on smooth hammered forgings, composite die sections, cast-to-shape tool steels and a new steel finder. Latter gives details on various forging and casting steel grades made. 30 pages. Allegheny Ludlum Steel Corp.

Circle 433 on page 19

DC Motors

Direct-current motors, ⅛ through 200 hp, and motor-generator sets up to 200-kw output are detailed in bulletin 53B8424. Construction, design and performance data are included. 6 pages. Allis-Chalmers Mfg. Co.

Circle 434 on page 19

Heat Exchangers

Heat transfer characteristics, dimensions, pressure drop and other design data on Alcotwin fin-tube heat exchangers are contained in bulletin FH-3. Various metals and alloys constructions are available for specific fluid services. 8 pages. Alco Products, Inc.

Circle 435 on page 19

Circle 579 on page 19→

there's a combination starter you KNOW is Safe!

Bulletin 712 Combination Starter consists of a standard Bulletin 709 across-the-line starter mounted in a cabinet with an A-B manual disconnect switch. Fuse clips are optional.

OPERATING LEVER CAN BE PADLOCKED IN "OFF" POSITION

You can use from one to three padlocks to lock this starter in the "off" position—or, for unusual applications, change it to permit padlocking in the "on" position.

TO OPEN COVER LEVER MUST BE IN "OFF" POSITION

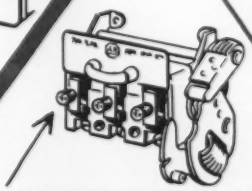
The disconnect switch lever is so interlocked that the cover of the cabinet cannot be opened until the disconnect switch is "open" and the starter is "dead."

COVER ITSELF CAN BE PADLOCKED

Provision for locking the cover to the base of the cabinet with a padlock eliminates all possibility of tampering with the mechanism.

INSULATING SHIELD COVERS "LIVE" LINE TERMINALS

With the cover open, only the incoming line terminals are "alive"—and in Allen-Bradley Bulletin 712 starters, these are covered with an insulating shield.



MOVABLE CONTACTS ARE PLAINLY VISIBLE IN "OFF" POSITION

When in the "off" position, the movable disconnect switch contacts show above the arc hood in plain view. Welded or sticking contacts can be detected instantly—a reliable safety signal.

BULLETIN 712 COMBINATION STARTER

Five distinct safety features give "plus value" to this new line of Allen-Bradley Bulletin 712 Combination Starters. And—you also get the design simplicity and the many other advantages for which the Allen-Bradley solenoid starter has earned its "quality" reputation.

Available in NEMA Types 1, 4, 7, 9, and 12 enclosures, from 1 to 100 hp, 220v; 200 hp, 440-550v.

8-56-MR

A-B Quality

ALLEN-BRADLEY

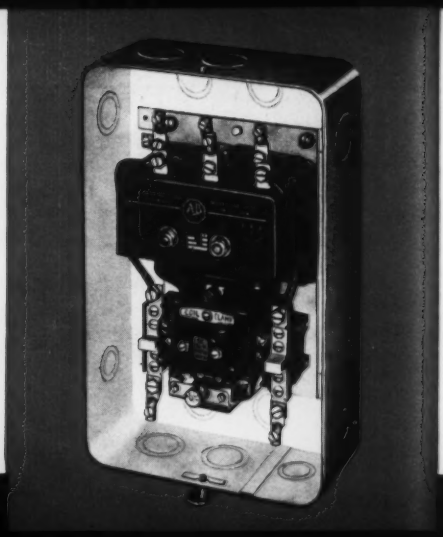
MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

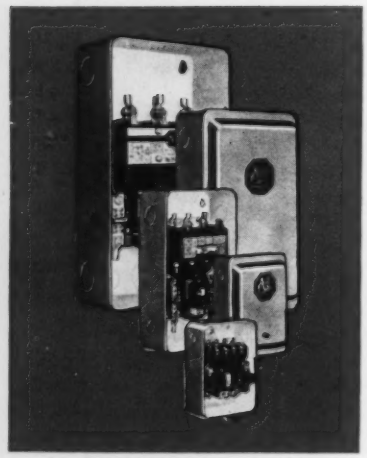
XUM

This simple design remains "tops"



Only one moving part—

that's why it's good for millions of operations!



Shown above are five sizes of the Bulletin 709 across-the-line solenoid starters. Three larger sizes are also available with a maximum rating of 300 hp, 220 volts; 600 hp, 440-550 volts.

The solenoid plunger shown above is the only moving part in any Allen-Bradley solenoid starter. Its straight up-and-down action is practically frictionless. There are no pivots, pins, or hinges to stick and cause trouble. That's why you are assured of millions of trouble free operations.

All Allen-Bradley solenoid starters have double break, silver alloy contacts that never need service attention of any kind. You just install them and forget them. On more and more automatic production machines, where continuity of operation is a "must," Allen-Bradley motor starters are standard equipment. Try them on your tough jobs!

A-B Quality

ALLEN-BRADLEY
SOLENOID MOTOR CONTROL
QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

8-56-MR

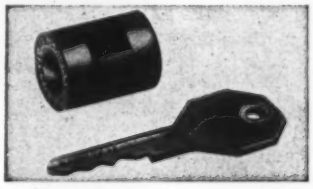
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Flexible Coupling

in miniature sizes from 1/8 to 5/16-in.

Miniature flexible coupling has die-cast aluminum or brass bodies and one-piece spider of Buna-N. Buna-N is equal to rubber in elasticity, strength, resilience, and resistance to abrasion and is superior in resistance to oils, chemicals, heat, ozone, and aging. Rating is 1/20-hp at 1750 rpm, range is 0.003-hp at 100 rpm to 0.103-hp at 3600 rpm. Dimensions are 5/8-in. OD



by 3/4-in. long. Bore sizes are 1/8, 3/16, 1/4, and 5/16-in. Applications include coding devices, film-type and tape recorders, actuators, dispensing machines and aircraft components. **Lovejoy Flexible Coupling Co.**, Dept. MDC, 4801 W. Lake St., Chicago 44, Ill.

Circle 451 on page 19

Pressure Switch

subminiature unit for absolute air pressure

Subminiature absolute air pressure switch has high resistance to shock and vibration and is designed to military specifications for use within temperature range of −55 C to +85 C. Unit responds to absolute pressure changes within ±0.5 psi. Other pressure ranges, pressure differentials and temperature ranges are available. Nine models cover range from 5.5 psia with switch open and 7.5 psia with switch closed, to 21.5 psia (switch open) and 23.5 psia (switch closed). Maximum pressure over-

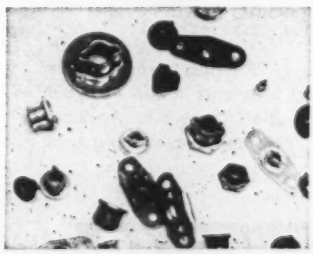
load is 45 psia. Electrical rating is 110 v ac or 28 v dc, 5 amps, non-inductive. Switch is single-pole single-throw, and insulation resistance is 10,000 megohms min. at 500 v dc. Unit has 1/8-in. NPT or 3/8-24 NF-2 threads, is 1 5/32 in. diam, 2 7/16 in. long, and weighs 2 1/4 oz. **Newark Controls Co.**, 15 Ward St., Bloomfield, N. J.

Circle 452 on page 19

Self-Locking Nut

in range of sizes from No. 4 to 5/16-in.

Self-locking nut, available in a wide range of shapes, is vibration-proof and unaffected by heat or weather. Nut is readily installed with standard tools and may be reused repeatedly without impairing locking ability. As a screw is inserted, nut is spread apart slightly, exerting



a concentrated pressure which grips screw without injury to threads. Unit is available in cadmium-plated steel or other materials in a size range from No. 4 to 5/16-in. **ConTorq Inc.**, North & Judd Mfg. Co., New Britain, Conn.

Circle 453 on page 19

Tachometer Generator

is self-compensated against temperature variation

Available in one of two basic models based upon amount of compensation desired, new dc tachometer generators hold output variation to less than 0.1 per cent, and voltage variation to less than 0.25 per

cent, within temperature range of −40 C to +100 C. External compensating networks are eliminated. Generators are available in six frame sizes and mounting types. Outputs are from 1 to 175 v per 1000 rpm, with operating speeds up to 10,000 rpm or higher. **Electric Indicator Co.**, 100 Camp Ave., Springdale, Conn.

Circle 454 on page 19

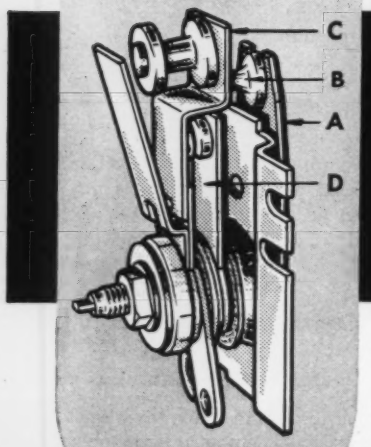
Overrange Protector

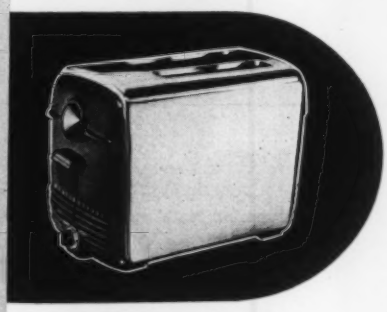
guards pressure gauges

Leak-proof sealing and accurate cracking characteristics of valves provide absolute, automatic protection for gauges. Where gauges are cascaded to provide accurate pressure readings over a wide range of system pressures, each gauge is protected. When system pressure rises above pressure range of individual gauge, relief valve in gauge

HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE

WESTINGHOUSE





Pop-Up Toaster

Westinghouse Elec. Corporation Mansfield, Ohio

Uniform toasting in just 90 seconds is featured by this new Westinghouse pop-up toaster. A new type of heating element is combined with a reflector on each side of the two slices. Its unique dual element thermostat compensates for variations due to voltage fluctuations and reduced browning of the second and third slices. The controlling elements are accurate, dependable Chace Thermostatic Bimetal, of course.

The operation of the thermostat is ingenious: the right hand bimetal element (A) controls the temperature of the air in the toasting chambers, hence the degree of browning. This highly responsive bimetal is positioned so it is exposed to the radiation from the heating element. High voltage (more heat) makes the element deflect to the left and the ceramic point (B) moves the upper spring-mounted contact arm at (C), opening the circuit, thus preventing over-browning. When voltage drops, the effect is opposite.

The left hand bimetal element (D) controls browning of second and third slices. Being of a much less responsive type, it is gradually deflected to the left by the ambient temperature in the toaster, moving the contact arm (C) and prolonging the period of the circuit.

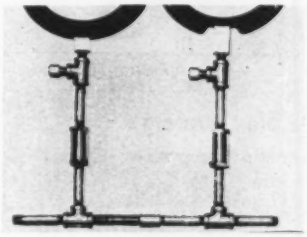
Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal, formulas, calculations, etc.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Circle 580 on page 19

New Parts

circuit opens to prevent exceeding gauge's maximum pressure and check valve, acting as excess flow valve, closes to block gauge off from system pressures. When system pressure falls to gauge's operating range, valve arrangement automatically opens to allow gauge



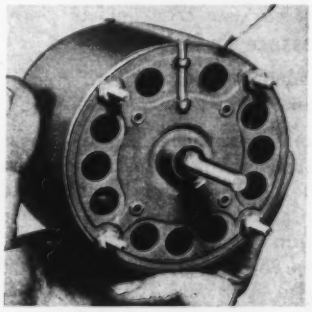
to register. System also furnishes protection in event of rupture of Bourdon tube. Fluid flow causes check valve to close immediately, sealing dead tight. System is protected against loss of liquid or gas, personnel are not exposed to blasts of gas or liquid, and area around gauges is kept free of fluids in system or gauge line. **Circle Seal Products Co. Inc.,** 2181 E. Foothill Blvd., Pasadena 8, Calif.

Circle 455 on page 19

Electric Motor

small motor in ratings of 1/250 to 1/15-hp

Small electric motor has excellent performance characteristics and increased starting and running torque. Stator core frame is a die casting. Both stator core registers are machined at once, insuring concentricity with each other and to bore. End frames are set in ma-



chined registers to provide positive bearing alignment and uniform air gap for quiet operation. Thermosetting phenolic end-turn insula-

NOTHING *can equal* *Stainless Steel*

for its combination of desirable properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When seeking a source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

For Consumer Appeal. General Ionics Corp. is the first company to offer an all Stainless Steel water conditioner. Sales have boomed because of its handsome appearance and complete freedom from corrosion problems. The company even offers a 10-year warranty to prove their faith in USS Stainless Steel.

For Long Life. All over the country, dairies are switching to Stainless Steel milk cans because they never have to be plated, the smooth surface does not harbor milk solids and bacteria, and, for all practical purposes, the Stainless milk can simply will not wear out.

For Corrosion Resistance. Laboratory fume hoods at the New Jersey Zinc Company used to last no more than 18 months—and sometimes they looked like sieves after only three months. They replaced the hoods and piping with Stainless Steel, and after five years they still look like new.

UNITED STATES STEEL CORPORATION, PITTSBURGH
AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

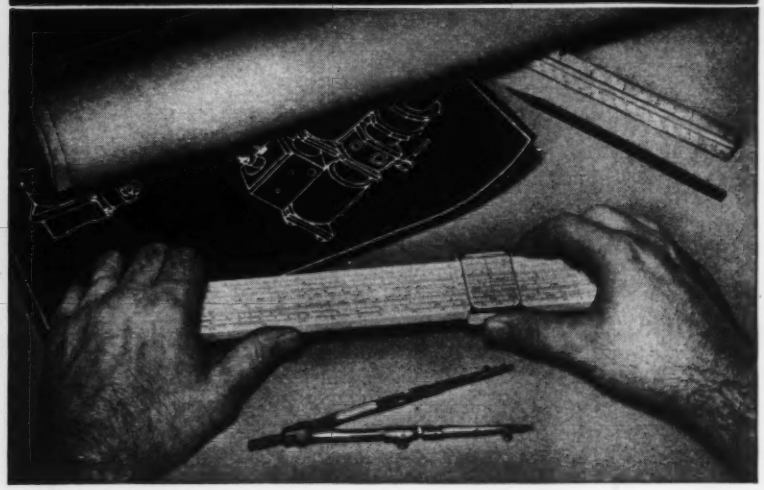
SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

USS

UNITED STATES STEEL

Circle 581 on page 19

FILTER FORUM



Question:

What facts should a product designer determine before choosing a filter?

Success of any pre-planned filter installation is dependent on calculations which are fundamental to the special field of filter design. As a rule, the data is simple to determine. Where unusual conditions exist, Purolator will design special filters to handle them.

Answer:

These five facts: 1. Degree of filtration, 2. Flow rate, 3. Contamination to be removed, 4. Viscosity of fluid, 5. Provision for cleaning or replacement.

1. Degree of filtration of a filter medium means the size of the smallest particles filtered out with 98% efficiency—expressed in microns for sizes less than .001 inch.

2. Flow rate is the flow that a clean filter unit will handle calculated in terms of the fluid's viscosity and the allowable pressure drop through the filter.

3. Contaminants are any elements from water to dust that shouldn't be there—the materials themselves, their quantity, their size.

4. As a rule, the pressure drop through a filter for a given flow rate is proportional to its viscosity.

5. Provision for cleaning or replacement depends on the predicted effects of a temporary lack of filtration while the cleaning or replacement is accomplished. Can the equipment operate temporarily without filtration, for example, can it be shut down periodically — or will two filters be needed; one for cleaning, one for service.

MAIL COUPON FOR DESIGN INFORMATION

PUROLATOR

FIRST in the field of filtering

Dept. D11-108, Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N. J.

Please send me the following filter information:

_____ Purolator's new "Filtration Manual for Designers". I'm enclosing 25¢ to cover postage and handling.

_____ Enclosed is a description of our filter problem. How should we solve it?

NAME_____ TITLE_____

COMPANY_____ ADDRESS_____

CITY_____ ZONE_____ STATE_____

New Parts

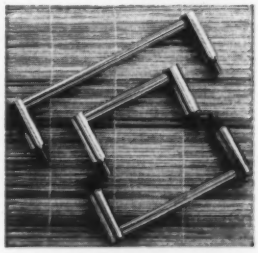
tors eliminate motor shorts and grounds. Housing studs are case-hardened to prevent thread stripping. Oil wicks are spun nylon, giving increased capacity and retention and more uniform oil distribution. Type AL-4 motor is 4-pole design, 1550 rpm, 115 or 230 v, 60 cycles. Motor is available in odd voltages and frequencies, open ventilated or totally enclosed. Ratings are 1/250 to 1/15-hp. Applications are heating, air conditioning, refrigeration, and appliances. **Redmond Co. Inc.**, Owosso, Mich.

Circle 456 on page 19

Instrument Handle

with crossbar lengths of 3 to 6 in.

Economical, adjustable instrument-handle is available with crossbar lengths from 3 to 6 in. in increments of ⅛ in. Handles are made of nickel-plated brass, with other



finishes available. Adjustable handle allows customer to use one type handle for many applications, and allows greater tolerance in center distance of mounting holes. **U. S. Engineering Co. Inc.**, 521 Commercial St., Glendale 3, Calif.

Circle 457 on page 19

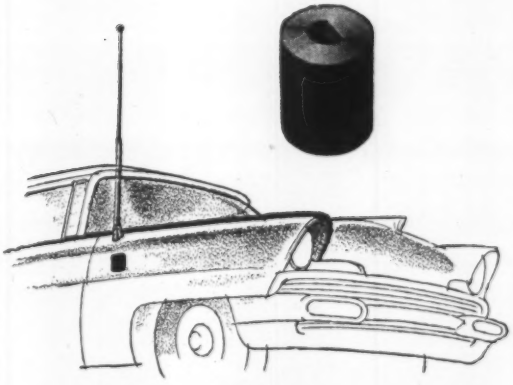
Pilot Light

subminiature unit has rotatable lens

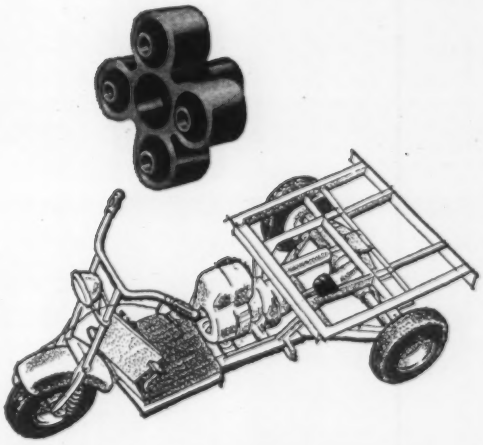
Pilot light has figure, letter, or word hot-stamped into flat face of translucent plastic lens. Light bulb is just below surface of lens, giving bright, even distribution of light. Legends are filled in for sharp contrast. Spring-mounted lens assembly rotates smoothly, enabling positioning after pilot light is screwed in place. Assembly unscrews from front of panel for replacement of lamp, which is mid-

Circle 582 on page 19

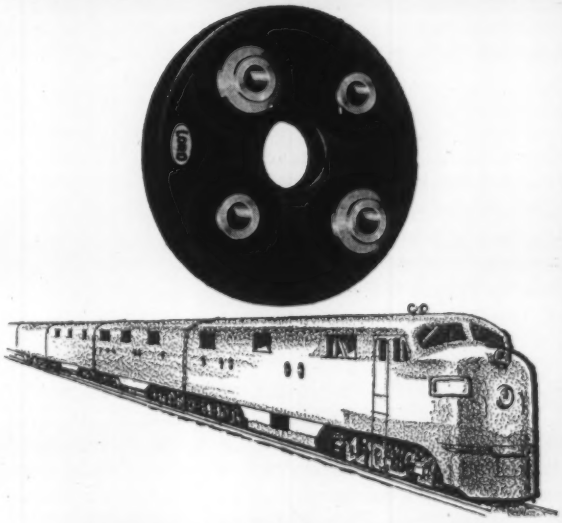
no lubrication, less vibration and noise with low-cost **LORD** flexible couplings



1/50 hp @ 5000 rpm—Flexible coupling to drive electrically actuated radio antenna on automobiles was Lord-designed to overcome noisy operation of all-metal unit. In addition to noise reduction, coupling accommodates 8° misalignment.



5 hp @ 3200 rpm—Low-cost Lord Flexible Coupling replaced costlier universal joint on three wheel industrial motor scooter. Used on drive shaft, it accommodates misalignment, eliminates lubrication.



300 hp @ 1200 rpm—Lord engineered this flexible coupling for a high-capacity application on locomotive auxiliary drive shaft. Unit provides desired vibration isolation and noise reduction, also accommodates slight shaft misalignment.

LORD engineers have special skills in designing Flexible Couplings for your specific requirements. Precision LORD bonded rubber units such as the examples shown here, effectively reduce noise and vibration on all types of installations from small automotive units to huge locomotives.

Bring your special flexible coupling problems to LORD. Specialized LORD engineering has solved many complex coupling problems and can probably solve yours with a low cost, high-efficiency bonded rubber coupling that will give outstanding performance. Simply call or write the LORD Field Office nearest you or the Home Office today.

LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

NEW YORK, N. Y. - Circle 7-3326
CLEVELAND, OHIO - SHadyside 9-3175
DETROIT, MICH. - TRinity 4-2060
DALLAS, TEXAS - Riverside 3392
PHILADELPHIA, PA. - LOcust 4-0147
DAYTON, OHIO - Michigan 8871
CHICAGO, ILL. - Michigan 2-6010
LOS ANGELES, CAL. - HOllywood 4-7593
BOSTON, MASS. - HAncock 6-9135
"In Canada—Railway & Power Engineering Corporation Limited"

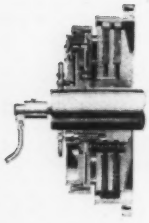
LORD BONDED RUBBER

designers and producers of bonded rubber products since 1924

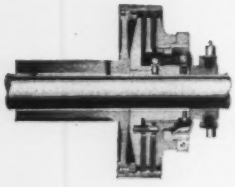
Circle 583 on page 19

Dependability First!

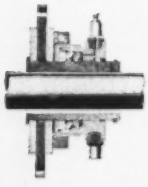
DODGE CLUTCHES



DODGE AIR-GRIP—quickest acting, most responsive air clutch available. May be "inched" or thrown into full engagement, as required. Built-in quick release valves, optional. Unique design and automatic internal ventilation insure cooler operation, longer life. Provision for mechanical engagement if air supply fails. Single and double plate types.



DODGE DIAMOND D—ruggedly built of highest grade materials, to resist wear and withstand shock loads. Smooth, trouble-free operation. Relatively light force on shifter is converted into a heavy power transmitting pressure between friction surfaces. One point shifting mechanism. Compact, completely enclosed for safety and protection from dust. Precision-built in sizes rated from 20 to 330 hp at 100 rpm.



DODGE ROLLING GRIP—simple and compact in design—no toggles. All working parts easily accessible. Power transmitting pressure on friction disc is developed by circle of hardened steel balls forced into wedge-shaped groove by the sliding cam. Flexible, easily controlled, extremely rugged. Single and double friction plate designs, sizes .38 to 21.2 hp at 100 rpm.

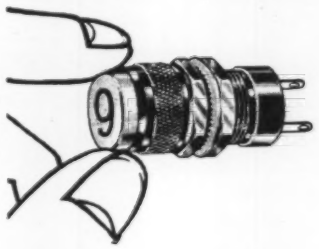
Write us now for Bulletins on Dodge Clutches.

DODGE
of Mishawaka, Ind.

Call the Transmissioneer, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone directory, or write us.

DODGE MANUFACTURING CORPORATION, 3300 UNION ST., MISHAWAKA, INDIANA

get flanged-base T-1-¾ incandescent, in voltages of 1.3, 2.7, 6.0, 14.0, and 28.0. Designated Series 143-3830-375, light conforms to all applicable military specifications. Optional features include choice of lens color, solder or taper-tab



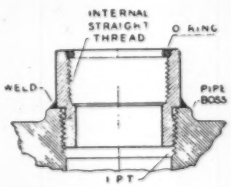
quick-connect terminals, and mounting from back or from front of panel. Units are 9/16 by 1¼ in. **Dialight Corp.**, 60 Stewart Avenue, Brooklyn 37, N. Y.

Circle 458 on page 19

Thread Adapter

for pipe to straight thread

Adapter is for use on valves and similar units with pipe threads to enable use of straight-thread tube fittings. Design allows welding



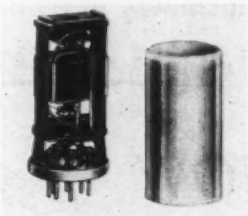
after adapter is in place to form a permanent leak-proof joint. **Parker Appliance Co.**, Tube & Hose Fittings Div., 17325 Euclid Ave., Cleveland 12, O.

Circle 459 on page 19

Miniature Relay

has sensitivity to 50-0-50 ma

Relay is housed in tinned-finished case and is supplied for miniature 7-pin socket mounting or with curved terminals for solder connection. Sensitivities as high as 50-0-50 ma at coil resistance of 2300 ohms are available. Nonmagnetic contacts carry 25 ma at 6 v dc (noninductive) at high sensitivity. Loads up to 0.5-amps at 28 v



dc (noninductive) can be handled. High and low contacts can be arranged for zero center, single-pole double-throw operation or suppressed zero with one contact normally-closed. **Weston Electrical Instrument Corp.**, 614 Frelinghuysen Ave., Newark 5, N. J.

Circle 460 on page 19

Acrylic Sheet

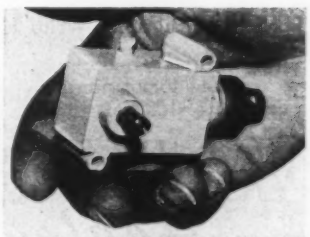
has excellent forming characteristics

Extruded acrylic sheet, available in clear and standard colors, shows good clarity and finish, and is free of extrusion lines or other marks or blemishes. Free of internal strain, the sheet has excellent machinability, vacuum forms and drape forms well, and may be deep drawn. Sheet holds close thickness tolerances and gives minimum shrinkage at forming heats. It has excellent weathering characteristics. Acrylic sheet is stocked in 0.060, 0.080 and 0.125-in. thicknesses, in standard 49 in. widths and lengths as desired. **Cadillac Plastic and Chemical Co.**, 15111 Second St., Detroit 3, Mich.

Circle 461 on page 19

Rotary Switch

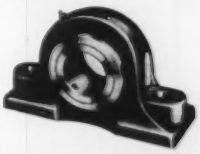
is rotary actuated hermetically sealed



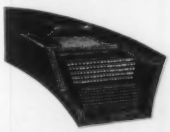
A flexible seal, formed of a Silastic compound, hermetically seals this rotary actuated switch. Seal has low leakage rate, less than one

DODGE PRODUCTS you should know

TAPER-LOCK
ALL-STEEL
CONVEYOR PULLEYS



SC and SCM
BALL BEARING
PILLOW BLOCKS



SEALED-LIFE V-BELTS

DODGE BULLETINS YOU SHOULD HAVE

1 TAPER-LOCK STEEL CONVEYOR PULLEYS. Construction details, sizes, dimensions. Bulletin D56.

1 ROLLING BEARINGS. Load ratings, dimensions and other data on Dodge-Timken and SC and SCM Ball Bearings. Bulletin A638.

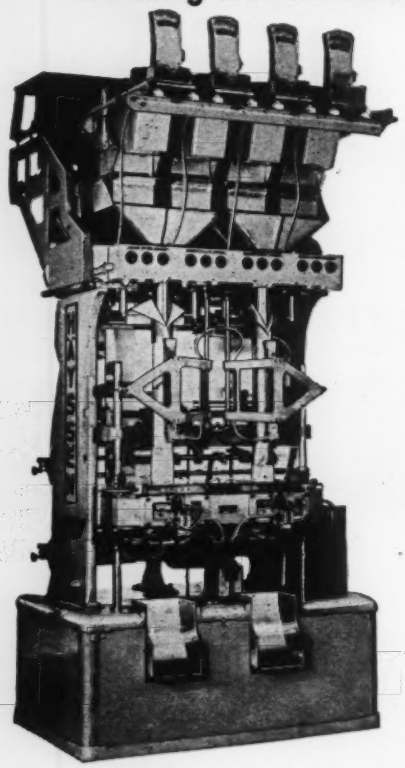
1 SEALED-LIFE V-BELTS. Construction details and data on sizes, pitch lengths and outside lengths. Bulletin A-606.

Write for your copies.
DODGE MANUFACTURING CORPORATION
3300 Union Street • Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

Circle 585 on page 19

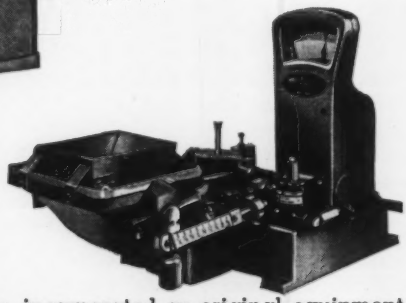
ONE MORE EXAMPLE of how EXACT WEIGHT Scales are being used in modern machinery design



Model 610
Net Weigher*

NOW

EXACT WEIGHT SCALES CONTROL ACCURACY IN HAYSSEN PACKAGING MACHINE



The EXACT WEIGHT Scales, incorporated as original equipment in the Hayssen Model "F" Compak Automatic Packaging Machine, control each filling operation with accuracy heretofore unattainable.

Weigh Feeders, developed by EXACT WEIGHT as original equipment for HPM Plastics Injection Molding Machines, provide more accurate measurement than is possible with volumetric feed.

EXACT WEIGHT Scales are now successfully used on milling machines to automatically weigh, balance, pre-set the machine and check the finished product.

EXACT WEIGHT Scales can be easily incorporated into the design of any machine that requires accurately controlled weight as part of its function.

Complete engineering data is available to designers. Write for free form #3305 to help you do a better job.

*The Net Weigher, shown above, is designed for original equipment installation. Write for complete details.

Exact Weight Scales

Better quality control
Better cost control

THE EXACT WEIGHT SCALE COMPANY

923 W. Fifth Avenue, Columbus 8, Ohio

In Canada: P.O. Box 179, Station S, Toronto 18, Ont.

Circle 586 on page 19

New Parts

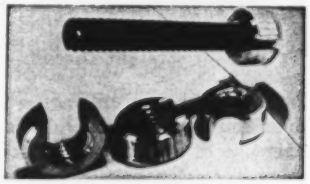
micron per cubic foot per hour, effectively sealing the switch against water, ice, vapor and dust. Temperature range is −100 F to +250 F. Switch may be wired externally from single-pole single-throw to double-pole double-throw, four-circuit, enabling four isolated circuits to be switched at one actuation (two normally open, two normally closed). **Electro Snap Switch & Mfg. Co.**, 4218 W. Lake St., Chicago 24, Ill.

Circle 462 on page 19

Split Nut

is locked in place with pliers

Slip-Squeeze, a nut of aluminum alloy, has one side machined away to allow placing on threaded rod when end is inaccessible or at a distance from desired point of application. Nut is positioned and



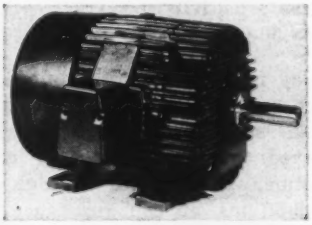
squeezed tight with pliers. Representative application is holding templates rigid while plaster mockups are being sculptured. A wide range of sizes is available. **Nutt-Shel Co. Inc.**, 811 Airway, Glendale 1, Calif.

Circle 463 on page 19

Electric Motors

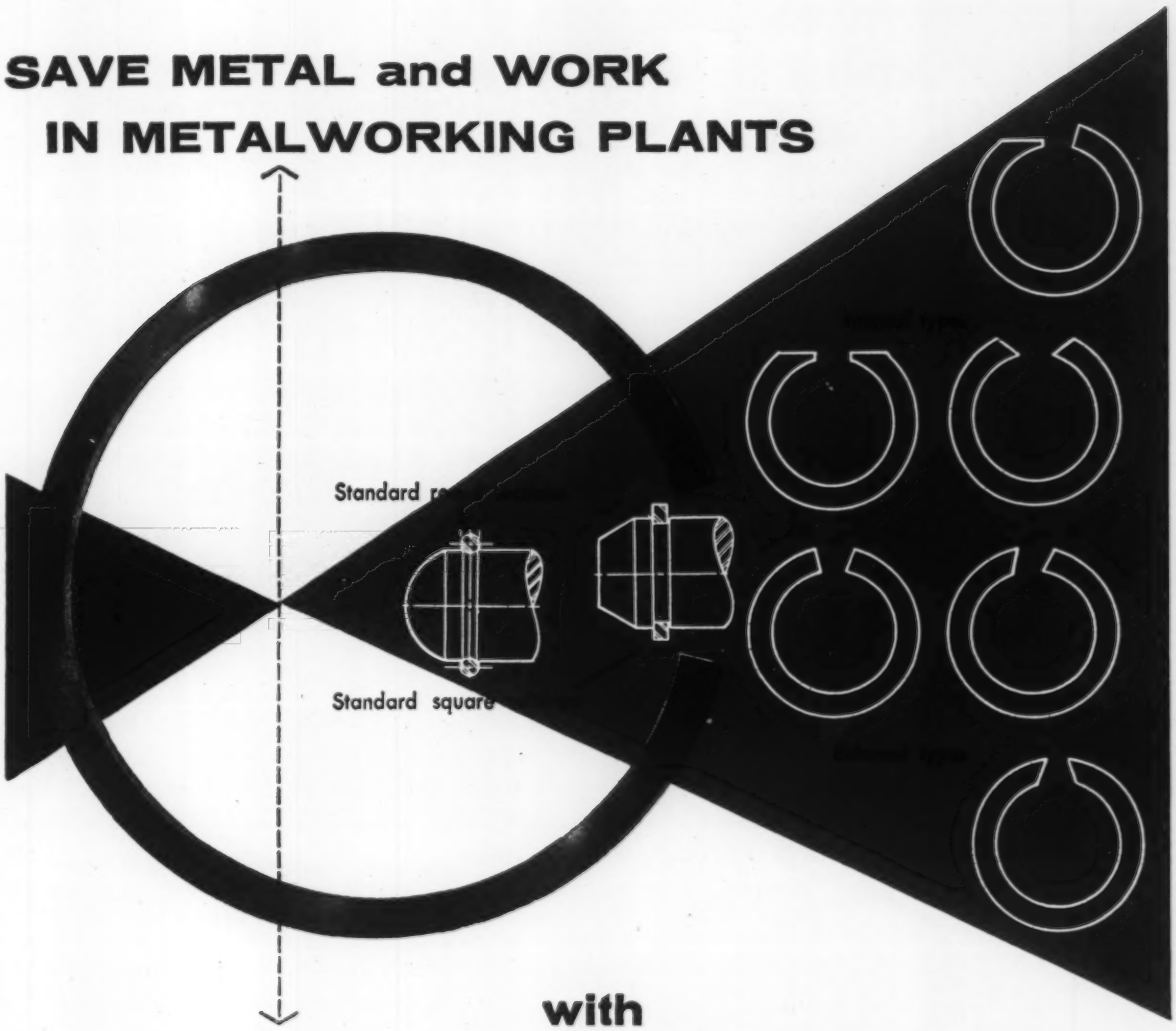
are redesigned units in sizes to 30 hp

Redesigned induction motors in NEMA frames are smaller, lighter, and more compact than former



models, and are available in sizes to 30 hp. Open-type motor is superseded by drip-proof motor, and

SAVE METAL and WORK IN METALWORKING PLANTS



with

RELIANCE SNAP RINGS

Looking for a way to reduce high product cost? There are two logical places to start . . . material and labor. Combined, these two factors are responsible for the major portion of the cost of any manufactured item.

Reliance Snap Rings are now being employed extensively by engineering and production men to reduce waste of valuable materials and at the same time cut expensive machining and assembly time. Previously it was necessary to machine an oversized shaft to form a shoulder. Now it is possible just to machine a groove and snap in a ring, saving metal from the machine shop floor and many hours of machining time. Snap rings can be used as bearing races, serve as shoulders on shafts or in counterbores. Reliance rings will save time and money for you as they have for so many others. Write for details contained in your free copy of Engineering Bulletin 55.

EATON

RELIANCE DIVISION
MANUFACTURING COMPANY
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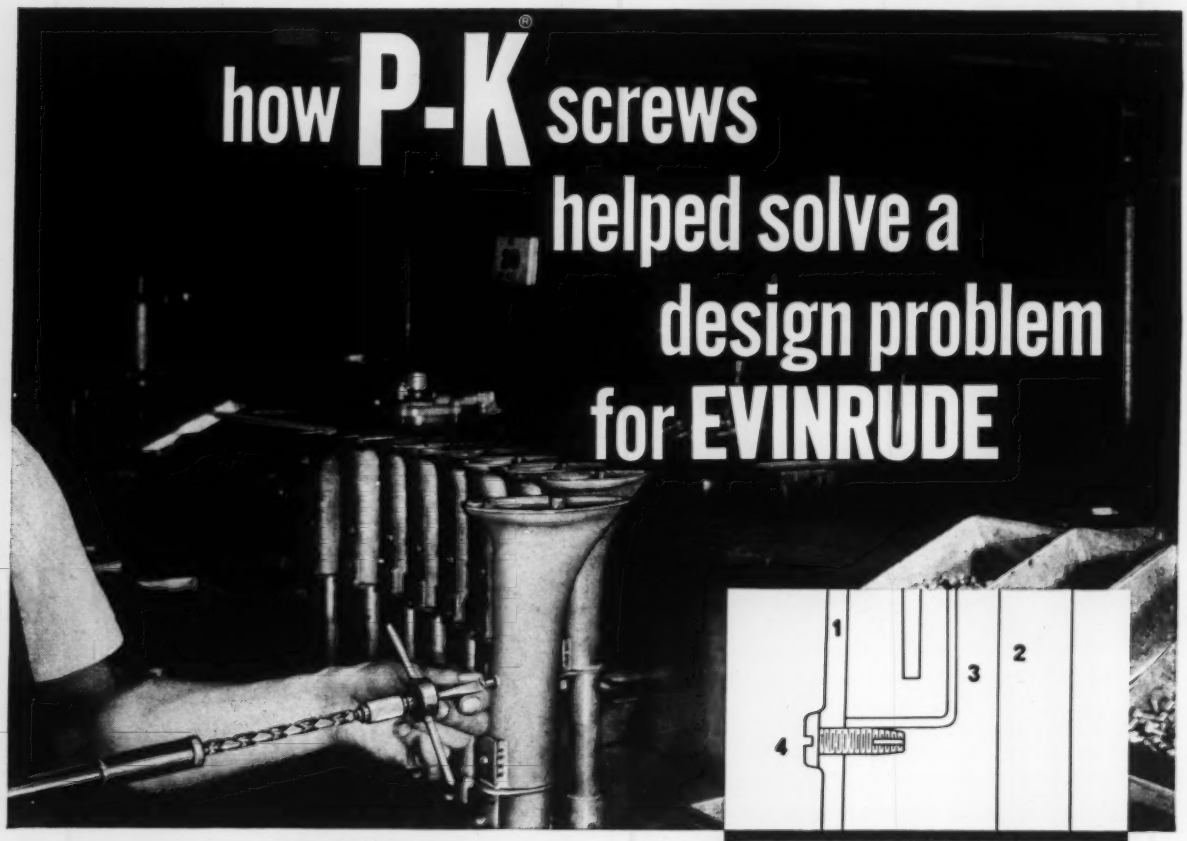
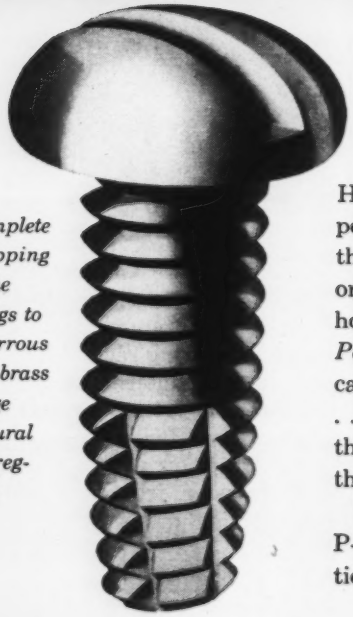
SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

XUM

how P-K® screws helped solve a design problem for EVINRUDE





Type F (one of a complete line of P-K Self-tapping Screws) used for the making of fastenings to ferrous and non-ferrous castings, bronze or brass forgings, heavy gage sheet metals, structural steel, plastics, impregnated plywood and other materials.

How do you keep a baffle from dropping down out of position? Designers of Evinrude outboard motors found the answer. No need for an expensive tapping operation or for a complicated stamping. Simply provide a cored hole in the casting, insert the stamping and then drive a *Parker-Kalon* Type F Screw through the hole in the die-cast housing. The screw acts as a retainer for the baffle . . . and because it is a *Parker-Kalon* Self-tapping Screw, there is no chance of its loosening during the operation of the motor. Yet it can be removed, if necessary.

This application is one example of the versatility of P-K Screws which designers can employ for various functions supplementary to fastening.

PARKER-KALON® fasteners

PARKER-KALON DIVISION, General American Transportation Corporation
Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws

Sold Everywhere Through Leading Industrial Distributors
Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois—Los Angeles, California

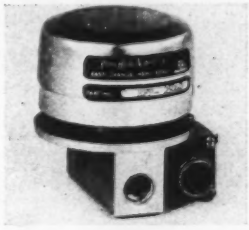
totally enclosed fan-cooled motor has redesigned ribbed frame. Motors have synthetic insulation which is high in dielectric strength and is resistant to damage from moisture, heat, abrasion, and corrosion. Open greaseable bearings are standard, but prelubricated cartridge-type bearings are available. **Elliott Co.**, Crocker-Wheeler Div., Jeannette, Pa.

Circle 464 on page 19

Solenoid Valve

for liquids to 3000 psi

Leakproof rotary solenoid valve handles most fluids, including liquid oxygen and nitrogen, at pressures to 3000 psi. Light-weight valve has straight through flow



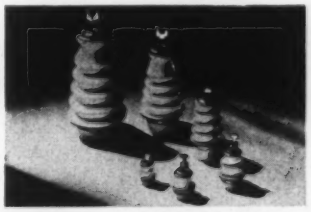
and functions over wide temperature range. Available either normally open or normally closed, valve is supplied for ¼, ⅜ or ½-in. tubing size. **Pneu-Hydro Valve Corp.**, 364 Glenwood Ave., East Orange, N. J.

Circle 465 on page 19

Alumina Terminal

simplifies soft-solder installation

Metal bonded alumina terminal allows strong, tight soft-soldered assemblies. Terminal provides bond-



strength stronger than materials involved, with excellent high-temperature ceramic-to-metal adherence. Metal-bond technique pro-

(*Continued on Page* 170)

Standard Quality sets Quality Standards

The day-in, day-out excellence, the quality which is standard in every Curtis Universal Joint, has made the Curtis Joint the quality standard of the industry.

Each Curtis Universal Joint component is made from specially selected steel, individually heat-treated for a specific purpose. This accounts for the long life and dependable performance of Curtis Universal Joints.

CURTIS UNIVERSAL JOINTS

- 14 sizes always in stock, ⅜" to 4" O.D.
- Fewer parts, simpler construction
- Complete equipment for government tests

Our catalog torque and load ratings are substantiated by constant tests. You can depend on them.

Not sold through distributors. Write direct for free engineering data and price list.

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UNIVERSAL JOINT CO., INC.

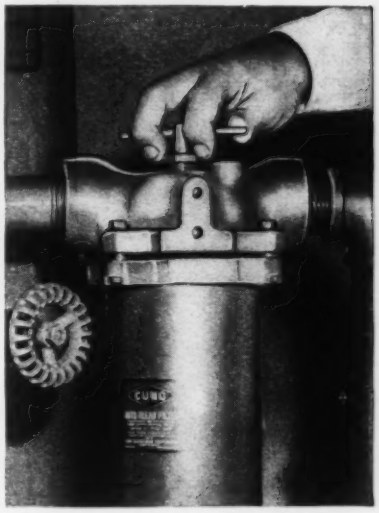
5 BIRNIE AVENUE, SPRINGFIELD, MASS.

As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 589 on page 19

FILTRATION NEWS



Filter to 40 microns, turn handle to clean!

You can clean this 40-micron filter simply by turning the handle at intervals—or turn shaft continuously with motor drive.

It's Cuno's SUPER Auto-Klean—using a completely new principle in metal edge-type filtration.

For compact, economical engine fuel and lube, machine-tool coolant and cutting oils, and a wide variety of process fluids, SUPER Auto-Klean offers:

Complete protection against solid particles larger than 40 microns—actually 0.0015". Can't rupture or channel.

No cartridge changes—just turn handle frequently to clean and, at intervals, remove plug and drain sump.

Low pressure drop—3 psi drop with flow rate to 45 gpm for 8" long by 2¼" diameter cartridge and fluid of 200 SSU viscosity.

All metal construction—available in stainless steel for corrosion-resistance.

Standard housings—available with Cuno's standard AUTO-KLEAN housing; available also for integral sump mounting.

Write today for complete data on this outstanding Cuno filter development. Ask for Catalog SAK-057. The Cuno Engineering Corporation, 14-10 South Vine Street, Meriden, Conn.

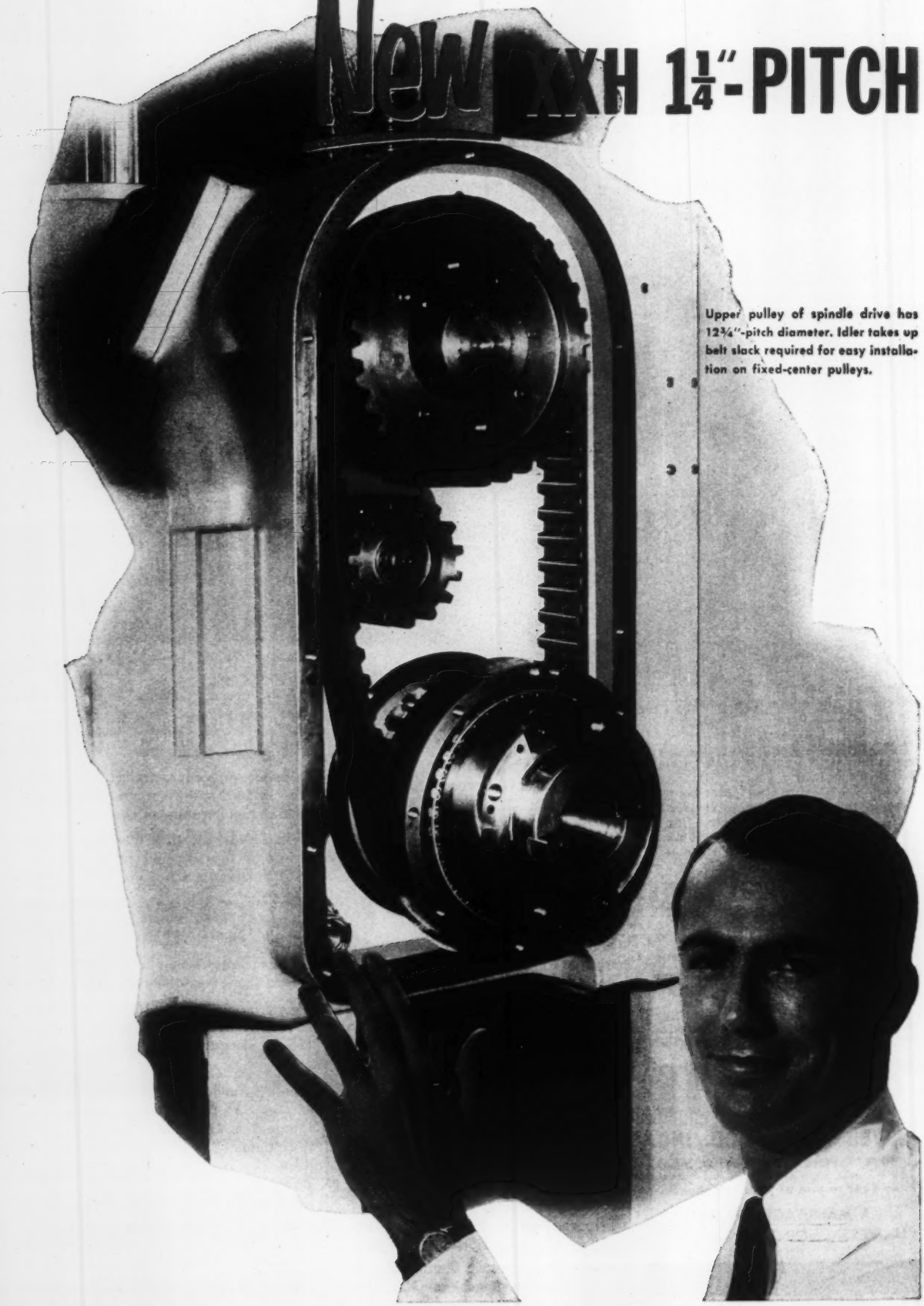
63

CUNO ENGINEERED FILTRATION

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge)
FLO-KLEAN (wire-wound) • PORO-KLEAN (porous stainless steel)

Circle 590 on page 19

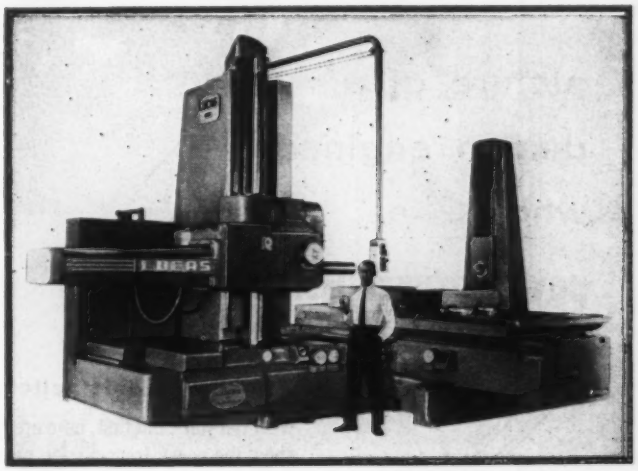
New XXH 1¼"-PITCH



Upper pulley of spindle drive has 12¾"-pitch diameter. Idler takes up belt slack required for easy installation on fixed-center pulleys.

Gilmer "TIMING" BELT DRIVE

gives boring machine a compact, vibrationless, cushioned spindle drive



HERE'S HOW a leading manufacturer* of heavy machine tools has made excellent use of the new Gilmer "Double Extra Heavy Duty" 1¼"-pitch "Timing" Belt drive. The close-up photo (with cover plate removed) shows the 3"-wide XXH drive which transmits the power of a 30 hp (1800 rpm) motor to the 6" spindle of a Lucas Model 684 or 6120 Horizontal Boring Machine. This drive is used for spindle speeds between 262 and 850 rpm.

Quoting from Lucas' own literature, this non-slip, steel-cable-reinforced, toothed belt "provides the smooth, positive, constant-speed drive required for high-speed boring, drilling or carbide milling. It is free from the vibrations which are normally imparted to the cutter by conventional high-speed gear drives."

Gilmer "Timing" Belt drives, with their constant angular velocity, have been standard equipment for some time on all Lucas Precision Horizontal Boring Machines... and on recent models of automatic bar machines made by Lucas' parent firm, The New Britain Machine Company. The recently introduced XXH size has enabled Lucas engineers to design a simpler, more compact "Timing" Belt drive for their largest machines.

Approximately 2½ times larger and 2½ times stronger than the ½"-pitch "Heavy Duty" series, the "Double Extra Heavy Duty" belt now, for the first time, enables machine designers to incorporate into drives up to 1000 hp the many advantages which have made the "Timing" Belt *industry's most versatile and most desirable form of power transmission.* For more details, contact your nearby NYB&P-Gilmer Distributor or write us direct.

**Lucas Machine Division, The New Britain Machine Co., Cleveland, O.*

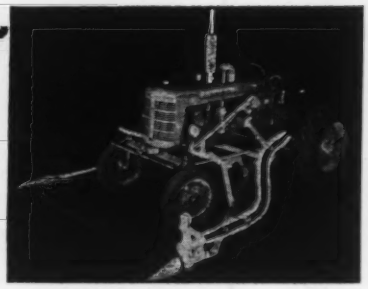
Gilmer **V-BELTS AND "TIMING®" BELTS**

NYB&P INDUSTRIAL RUBBER PRODUCTS

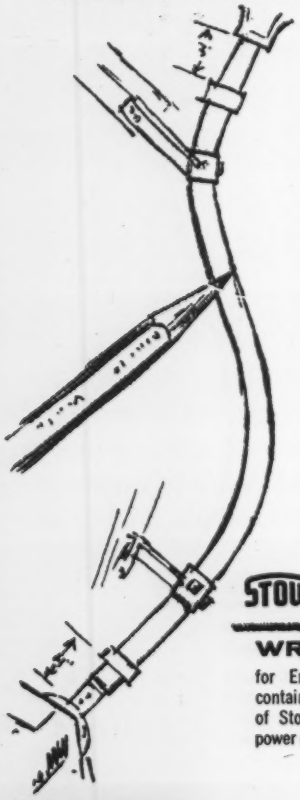
NYB&P — NEW YORK BELTING & PACKING CO. — Founded 1846

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products



picture of a
design engineer
who **had** a
power transmission problem



Know who this fellow is?

We'll tell you*, but first, here are the facts about the power transmission problem he licked with STOW flexible shafting.

Briefly, this company had the problem of supplying power to a mower on a farm tractor, from the tractor's power take-off which was 7 feet away. Raising and lowering the mower further complicated the problem because of the relative motion introduced between the ends of the shaft. Further, the drive used had to be dependable, economical, easy to maintain and safe.

*This Krengle's Inc. engineer found the answer in STOW flexible shafting. 1-inch shafting, with specially designed end terminals, was used for this job.

STOW your problems—
WRITE TODAY
for Engineering Bulletin 525 containing detailed information of Stow Flexible Shafting for power drives and remote control.

STOW
MANUFACTURING CO.
Originators of the Flexible Shaft
11 Shear St., Binghamton, N.Y.

New Parts

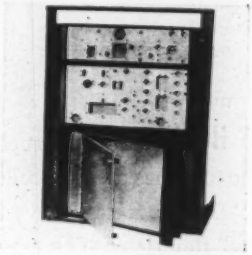
(*Continued from Page* 167)

vides an intimate bond which remains hermetically tight well beyond the temperature limits of soft-solder, thus allowing simplified assembly processes. **Carborundum Co.**, Stupakoff Ceramic Div., Latrobe, Pa.

Circle 466 on page 19

Swing Racks

provide front-access to electronic chassis

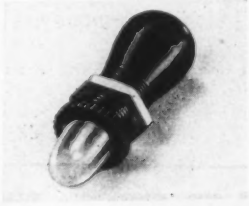


Lightweight sturdy front-access swing racks are available in three sizes: 8¾, 7, and 5¼ in. Racks are available in hinged frame with open-back chassis so that dust problems are minimized, and in hinged frame with hinged-front chassis where enclosure of the under-chassis parts is desirable. Both types of construction provide for access to under-chassis elements from the front of the panel by simply swinging the rack out. Combination of aluminum chassis and steel frame will support chassis weights up to 80 lb. **National Co.**, 61 Sherman St., Malden 48, Mass.

Circle 467 on page 19

Miniature Pilot Light

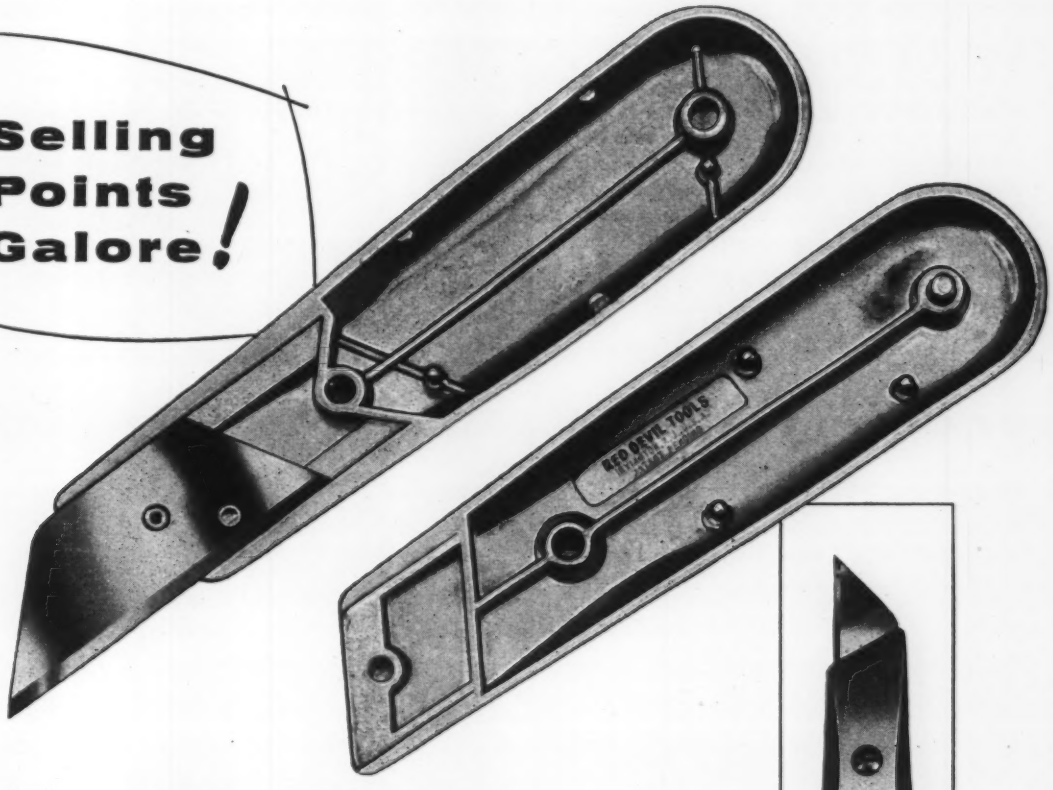
installs in ⅜-in. hole

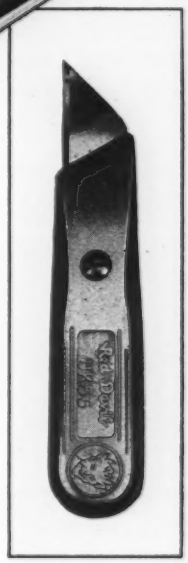


Miniature neon indicator light, designed for use with taper-pin terminals, extends only 1 1/16 in. beyond back of panel when installed. Front locking nut has ex-

Circle 592 on page 19

Selling Points Galore!





and the *telling touch* is

MADISON-KIPP

zinc and aluminum die castings

To finalize the sale of competitive "counter goods" quickly requires pre-planning and good judgment on the part of the product designer.

The skilled and experienced craftsmen at Madison-Kipp can often assist in providing the "telling touch" that might otherwise be missed.

Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

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210 WAUBESA STREET • MADISON 10, WIS., U. S. A.

• Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

XUM

up in the clouds...

When a Navy Training Plane points its nose skyward in defiance of gravity, everything from tip to tail must be a model of precision and endurance. Federal Ball Bearings are here, too, in the flexible drive assembly of this Lear actuating screwjack, which helps raise and lower the pilot's seat.

or down the lane!

Bowlers call it magic, the way the AMF Automatic Pinspotter sets 'em up—even replaces "off-spot" pins in their exact location after every roll. Federal Ball Bearings do their part in the gear boxes of these mechanical marvels.

so much of industry *turns* on FEDERAL ball bearings

Federal

Ball Bearings

One of America's Largest Ball Bearing Manufacturers

Pilot's comfort or bowler's score. Production manager's quota or housewife's cake. All are important to those who design and build so many of the thousands of tools, machines and household appliances —with Federal Ball Bearings. 12,000 sizes. Hundreds of types. Produced by this 50-year-old manufacturer of ball bearings, *exclusively.*

When Federal Ball Bearings are part of so many things you *use*, shouldn't they be part of the things you *make?*

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, N.Y.

New! Ball bearing and engineering data! 175 pages full in FEDERAL'S CATALOG! To get your copy, just drop us a line.

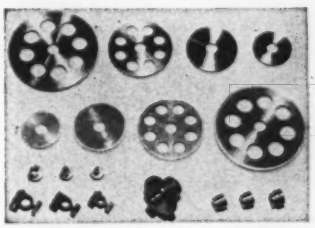
tra-deep knurling for quick assembly. Body is of black anodized aluminum and internally-fluted cap is lucite. Light is equipped with built-in current-limiting resistor. Two receptacles on one side of circuit provide easy installation of jumper wires. Units mount in ⅜-in. holes in panel, project outside 15/32-in., and may be mounted on ⅝-in. centers. **Drake Mfg. Co.,** 1713 W. Hubbard St., Chicago 22, Ill.

Circle 468 on page 19

Precision Gears

in pitches from 48 to 96

Precision spur gears are available from stock in 303 stainless steel, clear passivated, or 24ST aluminum, chromic acid anodized. Gears are cut to AGMA precision 1 toler-



ance with precision 2 available. Pitches are 48, 64, 72, and 96, pressure angle 20 deg, with 14½ deg pressure angle available. Gears fit type R3 slip clutch, K1 pin hub, and K2 clamp hub, in shaft sizes of ⅛, 3/16, and ¼-in. diam. **PIC Design Corp.,** 160 Atlantic Ave., Lynbrook, L. I., N. Y.

Circle 469 on page 19

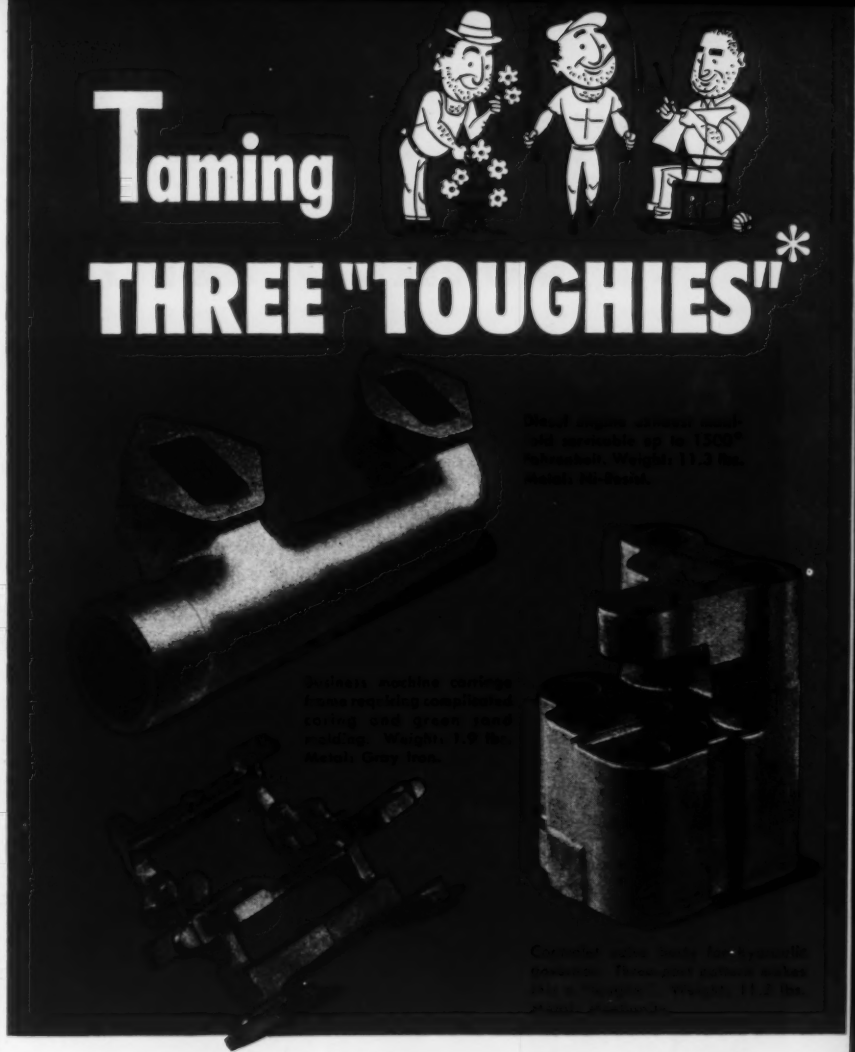
Miniature Relay

has drop-out within 5 per cent of pull-in

Small 3-pole double-throw relay has high accuracy of pull-in and drop-out, high repeatability, and resistance to shock and vibration. Normally adjusted for 20 v pull-in and 9 v drop-out, residual adjustment gives a variety of drop-out values between 9 v and 19 v. Adjustment, controlling differential between pull-in and drop-out, may also be used in constant-current circuits. High stability is maintained throughout entire voltage range over ambient temperature

(Continued on Page 176)

Circle 595 on page 19→



Turn your tough casting jobs over to Hamilton Foundry . . . the castings with intricate coring . . . wide range of metal thickness . . . tight dimensional tolerances . . . or high physical specifications. Hamilton thrives on licking the problem jobs.

Hamilton Foundry's skill and experience . . . seasoned engineers . . . and top quality control assure the correct translation of your specifications in the final product. Hamilton Foundry's wide variety of irons permits unusual flexibility of physical property ranges.

No matter how complicated the design, depend on HAMILTON QUALITY CASTINGS® for smoother, lower-cost production in your plant.

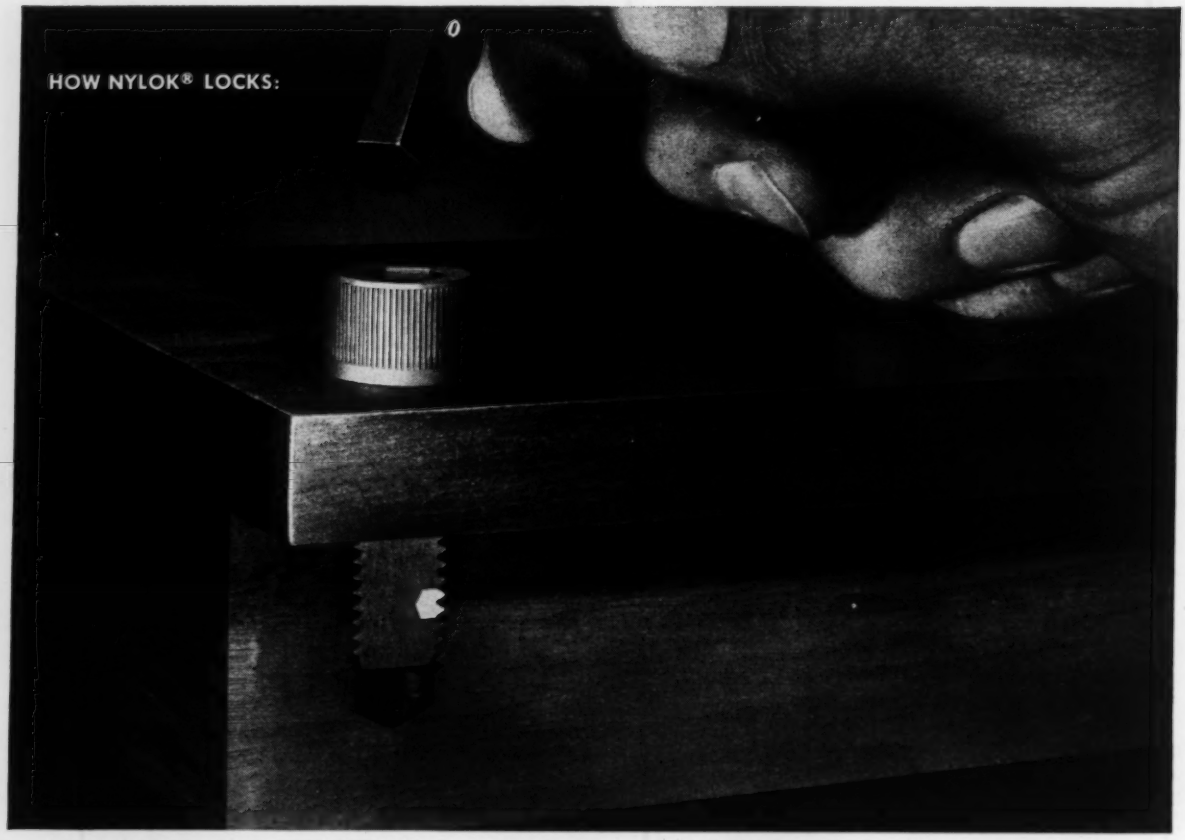
Call on Hamilton Foundry for your casting "toughies"

GRAY IRON • ALLOYED IRON
MEEHANITE • NI-RESIST • NI-HARD

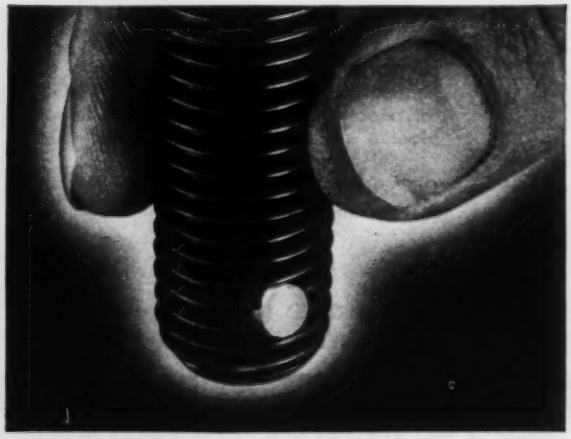
THE HAMILTON FOUNDRY
AND MACHINE CO.
1551 Lincoln Avenue • Hamilton, Ohio
Phone TWinbrook 5-7491

HDS-9

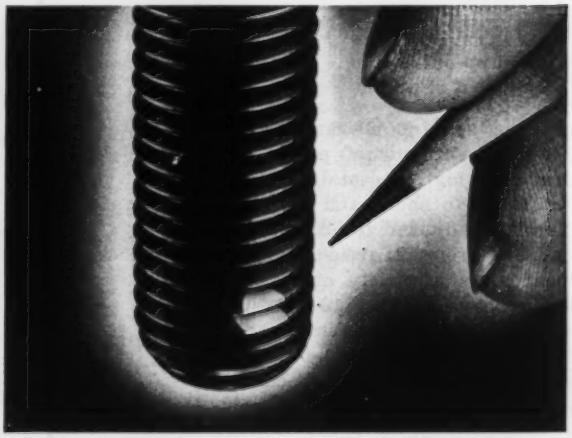
NEW—a complete line of socket screw products



LOCKED! The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together, and locks the screw securely.



BEFORE ASSEMBLY. The nylon pellet projects slightly beyond male threads. When assembled, female threads will be impressed into it. Pellet locks effectively whether the screw is seated or not.



AFTER REMOVAL. "Plastic memory" of pellet has expanded impressed threads to greater diameter than screw threads. Screw can be used repeatedly. In use, "memory" keeps threads tightly locked.

self-locking UNBRAKO that won't work loose

They simplify design and save production time

UNBRAKO socket screws are now available embodying the Nylok* self-locking principle. Nylok provides a truly practical new solution to the problem of making screws self-locking.

An UNBRAKO screw with Nylok is a single self-locking unit. No auxiliary locking devices are needed. Just thread the UNBRAKO into any tapped hole. *Seated or not*, it locks positively wherever wrenching stops. The tough, resilient nylon pellet forces mating threads together and holds tight. The screw will not shake loose.

You save production time when you build products with self-locking UNBRAKOS. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. So are cotter pins and complex multiple set screw installations.

Self-locking UNBRAKOS are completely reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, on properly seated screws, the pellet acts as a liquid seal.

Self-locking UNBRAKO socket screws come in a complete range of standard sizes and materials. See your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

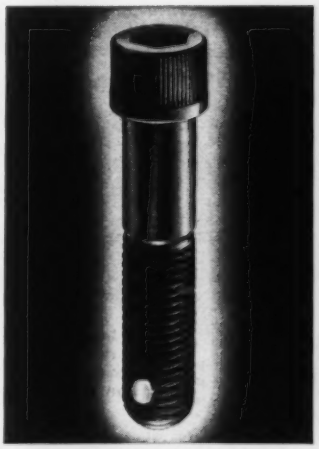
**T.M. Reg. U.S. Pat. Off., The Nylok Corporation*

UNBRAKO SOCKET SCREW DIVISION

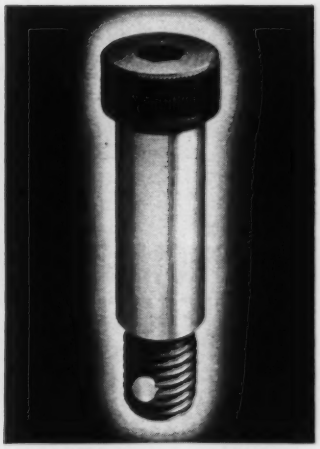
STANDARD PRESSED STEEL CO.

SPS

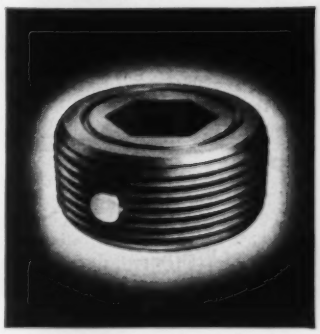
JENKINTOWN PENNSYLVANIA



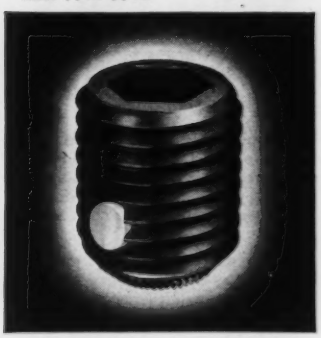
Socket head cap screws. Standard sizes #6 to 1 in.



Socket shoulder screws. Standard sizes ¼ to ¾ in.

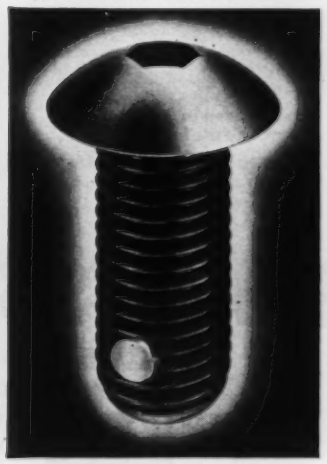


Socket pressure plugs. Standard sizes ⅛ to 1¼ in.



Socket set screws. All standard point types. Standard sizes #6 to 1 in.

Flat head socket screws. Standard sizes #6 to ¾ in.



Button head socket screws. Standard sizes #6 to ⅜ in.

Circle 596 on page 19

CASE HISTORY 1

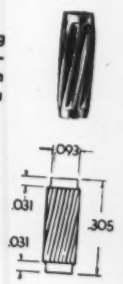
REQUIRED:
A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:
Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.

CASE HISTORY 36

REQUIRED:
Less costly manufacturing method for this small stainless steel fluted pin which cost $19.20 per M as a screw machine product.

HASSALL SOLUTION:
Cold forming by Hassall at a cost of $2.95 per M gave the customer an 85% cost reduction on this part.



CASE HISTORY 89

REQUIRED:
Customer looking for low cost, high production rate method of producing mandrels for rotary dental brushes.

HASSALL SOLUTION:
Hassall-originated design for cold-heading replaced chamfered end with tumbled, round end; maintained rigid specifications for straightness and made low-cost production possible.

CASE HISTORY 37

REQUIRED:
Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:
The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

SPECIALTY MANUFACTURER OFFERS SAVINGS ON SMALL PARTS AND FASTENERS

Multiply these case histories a thousandfold and you'll get some idea of the variety of tough problems we crack, and the savings we effect for our customers in the course of a year.

Our cold-heading process—supplemented by secondary operations—imposes amazingly few limitations on the parts and fasteners we can make. Don't forget that we are not limited to "stock" sizes. These illustrations show that Hassall—a specialty supplier—can show you substantial savings, better deliveries and technical assistance on your small parts and fasteners.

Proof? Send us your specifications or write for catalog.

John Hassall, Inc., P. O. Box 2197 Westbury, Long Island, New York.

HASSALL

SINCE 1850

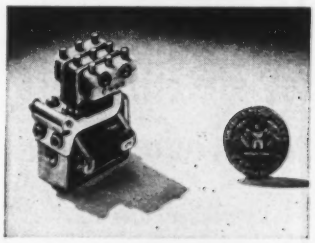
Hassall

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

New Parts

(*Continued from page* 173)

range of −60 to +125 C. Contact rating is 2.5 amps inductive and 4.0 amps resistive at 30 v dc; coil resistances range from 0.1-ohm to



6400 ohms. Mechanical life is 2 million cycles; electrical life is 100,000 cycles at 5.0 amps 120 v ac. Relay is 1⅝ in. high, 1½ in. long, and 1⅜ in. wide; weight is 3 oz. **Joseph Pollak Corp.**, 79-85 Freeport St., Boston 22, Mass.

Circle 470 on page 19

Magnesium-Thorium Sheet

for high-temperature applications

Elevated temperature magnesium alloy sheet contains thorium, zirconium, and manganese in various combinations. Alloy retains good short-time properties up to 800 F, and good long-time properties to 600 F. Material is corrosion resistant, and because of light weight, may be used in relatively thick sheets which resist buckling better than thinner sheets of heavier metals. Sheet is available in production quantities rolled in gages from 0.016 to 2 in. in hard-rolled (−H24) and annealed (−0) conditions. Primarily for aircraft development projects, alloy may be sheared, drawn, spun, arc welded, and spot welded. Severe drawing may be performed in temperature range of 600 to 700 F. **Dow Chemical Co.**, Midland, Mich.

Circle 471 on page 19

Interval Timer

is sealed against dust and dirt

Case of dust and dirt proof Model 102 interval timer serves dual purpose, acting as enclosure and insulator while providing support for switch blades. Steel cover requires no clearance and can be

when it may be a matter of

LIFE or death . . .

RELIABILITY of the Variable Speed Drive is **ALL-IMPORTANT!**

150 SERIES
⅛ to 1½ h. p.
This new series of drives runs at low input speeds, 1200 RPM and 1800 RPM.

GET Graham

most reliable variable speed drive made

SIZES FROM FRACTIONAL TO 3 H. P.

There are four sizes of Graham — each in a wide variety of styles. All drives may be had either with built-in motor or with input shaft extension for coupling or belting to separate motor or to a shaft of the machine. Controls are either single turn, micrometer, lever or remote electrical control with speed indication at the remote point. Built-in motors may be had of nearly any desired mechanical and electrical type, open, totally enclosed, explosion-proof, motor with built-in brake included.

6 OUTSTANDING FEATURES

- Ultimate in simplicity and compactness.
- Unlimited speed range — from any desired maximum down to zero — including reverse if wanted without stopping the motor.
- Unmatched for accuracy of speed setting and resetting and speed holding.
- No perishable parts.
- Twenty year performance record.
- Low cost.

COMPLETE LINE OF BUILT-IN GEAR BOXES

The Graham gives every speed from any desired maximum down to zero (including reverse if wanted, without stopping the motor). The Graham should be so selected that the desired maximum speed of the driven shaft is had when the Graham is running at approximately its top speed. When this requires reduction or step-up gearing, this may be had without the cost and complication of a separate gearbox since the Graham is available with built-in single reduction or step-up spur gearing, single reduction worm gearing with output shaft horizontal or vertical, and double reduction helical gearing. Only four mounting bolts are required for the entire assembly — transmission, built-in motor and built-in gearbox — the ultimate in compactness.

. . . that's WHY Allis-Chalmers specified the *Graham*

Here the Graham drives the Beck pump that takes the impure blood from an artery in the patient's arm and circulates it around the purifying means, returning it to the body through a tube in the leg. This artificial means of purification, has saved many lives in emergency treatment of uremic poisoning and other diseases.

Also, on the Maisch heart pump, the famous Mechanical Heart & Pump developed for Philadelphia's Jefferson Hospital (see photo), the Skeggs-Leonards Artificial Kidney, the Bird Respirator Pump and on countless other medical devices, the Graham Variable Speed Drive is selected, in preference to others.

This reliability of performance, has made Graham the preferred drive also for conveyor drives on critical operations, for stokers, chemical processing machines and a wide variety of other industrial equipment where breakdowns would be costly.

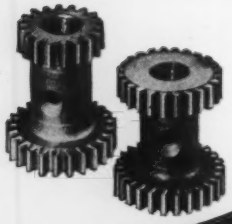
GET Graham
most reliable variable speed drive made

Because engineered and rated for continuous 'round the clock service

Mail This Coupon NOW . . .

GRAHAM TRANSMISSIONS, INC.
DEPT. MD, MENOMONEE FALLS, WISCONSIN
Gentlemen: Please send your latest catalog on *Graham Variable Speed Drives.*

Company.....
Name..... Title.....
Address.....
City..... Zone..... State.....



STOCK or SPECIAL

OHIO

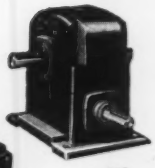
SPECIAL
GEARS AND SHAFTS

GEARS

Protect your product by specifying Ohio Stock — or Special gears to your specifications — Spur, Bevel, Miter, Helical, Worm and Worm Gears. Steel • Cast Iron • Hardened Steel • Bronze • Non-Metallic.

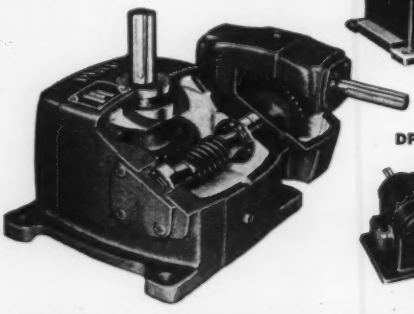
BEVEL GEARS

DHH2



HS

SPUR GEARS



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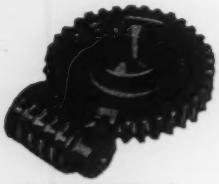


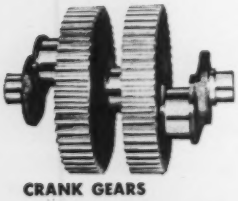
WORM GEARS

DOX

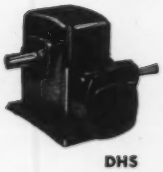
OHIO SPEED
REDUCERS

save you power transmission dollars whether "OFF THE SHELF" or SPECIAL in ratios of 4 — 1 to 3200 — 1 — Horizontal or Vertical — Single Worm — Double Worm — Helical — Motorized or Bevel.

See our nearest distributor or write direct.



CRANK GEARS



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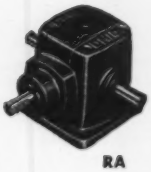

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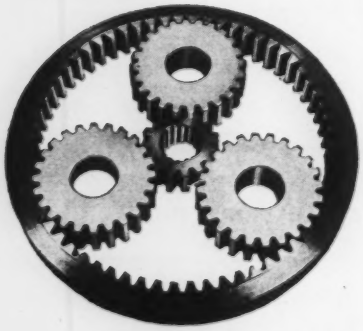


PLANETARY
GEAR CLUSTER

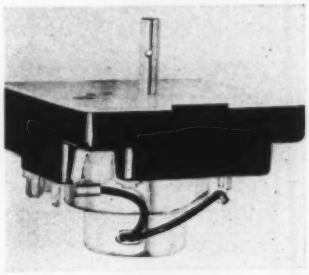
ESTABLISHED 1915

OHIO GEARS

THE OHIO GEAR CO.
1338 EAST 179th STREET
CLEVELAND 10, OHIO

New Parts

mounted flush to any surface. Rated at 25 amps 250 v, and designed for high capacity electrical



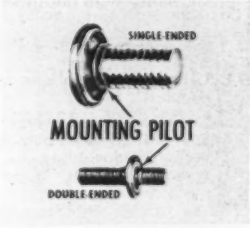
appliances, unit may also be used on low-capacity appliances wherever control for a preset time is desired. **Controls Co. of America,** Soreng Div., 9555 Soreng Ave., Schiller Park, Ill.

Circle 472 on page 19

Mounting Stud

is self-centering

Shoulder on this mounting stud serves as a pilot in locating mounting centers, insuring positive centering. Pilot eliminates need for locating-jigs during stud welding,



thus lowering production costs and rejections. Mounting studs are available in both single-ended and double-ended styles in a wide range of sizes. Material is carbon or stainless steel. **Heldor Mfg. Corp.,** 238 Lewis St., Paterson, N. J.

Circle 473 on page 19

Tachometer Head

has AN or SAE screw mount

Tachometer takeoff head measures speeds between 100 and 5000 rpm and is available with AN screw mounts for aircraft tachometer takeoff or with SAE screw mount for gasoline, diesel, marine, railway, or stationary engines and compressors. Rugged construction

How to Control Heat in a Large Oven

No. 4 of a series — *Showing the Broad Application Range of Fenwal Controls*

The oven is designed to dry 30 yards of finished goods per minute at oven temperatures up to 400°F. The problem was to maintain the desired 330°F in the oven. Here's how this was accomplished —

The many electric heaters, which are distributed uniformly in the oven, provide a total heat input of about 60,000 watts and are divided into two separate control circuits. About one-third of the heaters are controlled by a simple on-off controller of moderate sensitivity to maintain a basic heat level in the oven. The remaining heaters are operated by the Fenwal Series 560 Portable Temperature Indicating Controller, an instrument of high sensitivity and rugged construction. The Series 560 provides the proportioned heat necessary for accurate control of the curing process. It also can be used for straight on-off control. Here's the way the control set-up works —

To maintain the desired 330°F in the oven, the on-off controller is set at 315°F, while the proportioning controller is set at 330°F. So both heater circuits are on during oven warm-up or when incoming fabric depresses the oven temperature below 315°F. Above 315°F, the on-off controller shuts off the heaters in its circuit, and the process heat is obtained from the remaining heaters under the control of the Fenwal Series 560 Controller.

Integrated Sensitivity a Big Advantage in The Series 560

In the Fenwal Series 560 Temperature Indicating Controller the superior thermoelectric qualities of the revolutionary thermistor are used to fullest advantage. The great resistance change of the thermistor in response to temperature change results in extreme sensitivity. It also enables the use of a simple null balance bridge circuit for increased stability. And it permits the use of a standard electric conductor as a connecting wire — *no special wire is required.*

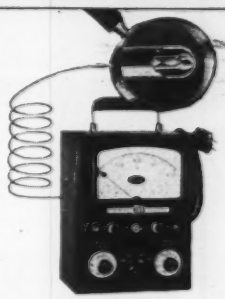
These characteristics have been *integrated* by Fenwal into a rugged, durable instrument which is the first to combine all three major modes of indicating control — on-off, proportional and adjustable differential — *all functioning with high sensitivity at the flip of a switch.*

THIS 600 CUBIC FOOT CURING OVEN, planned and installed by Atlas Textile Machinery Co., Paterson, N. J. at the Gsell Textile Printing Corp. plant in New York, uses the Fenwal Series 560 Portable Temperature Indicating Controller to provide uniform drying conditions within 2 degrees of the set point.

Proved Applications

Fenwal Sales Representatives and Engineers have saved time, trouble and money in all types of plants and laboratories by solving thousands of temperature control and detection problems. Fenwal THERMOSWITCH® units are controlling processes that involve liquids, gases and solids.

Put Fenwal's vast reservoir of technical know-how to work for you. Chances are your problem has already been met and mastered by Fenwal engineers. Write for Catalog No. 500 for complete information.



SERIES 560 INDICATOR CONTROLLER with magnified cutaway view of thermistor probe.

FENWAL INCORPORATED
1910 Pleasant Street
Ashland, Mass.

Please send me your Catalog No. 500. Our specific problem is:.....

.....

.....

Name.....*Title*.....

Address.....

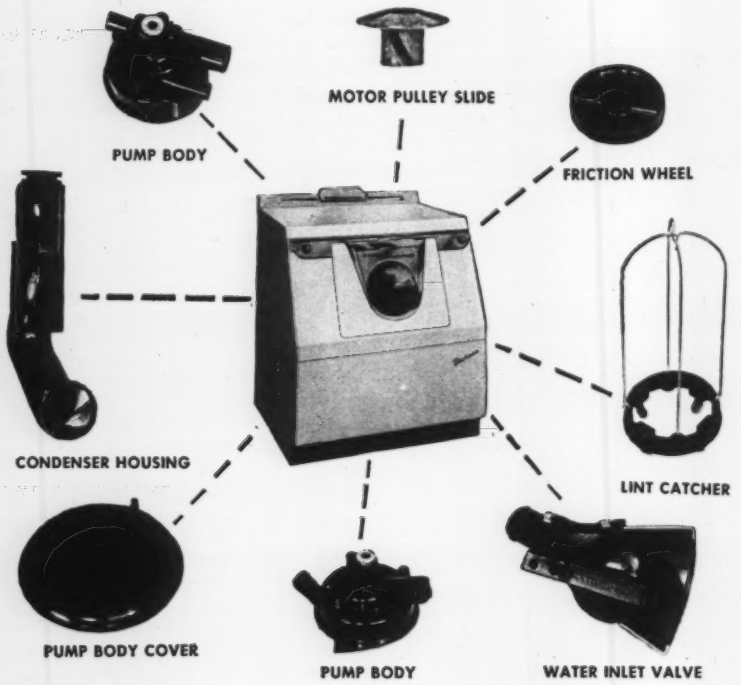
City.....*Zone*...*State*.....

Fenwal CONTROLS TEMPERATURE . . . *PRECISELY*

PRODUCT DESIGN WITH DUREZ PHENOLICS

WESTINGHOUSE

makes sure **8** *ways...*



with Laundromat parts of* **DUREZ** *phenolics*

Probably no single group of plastics offers design engineers such wide latitude in meeting specific service conditions as the Durez phenolics. These eight components now helping to implement the slogan "You can be sure if it's Westinghouse" are a notable example.

The problem was to create long-wearing, non-corrosive, economical parts of light weight for new Laundromats. All these objectives were achieved by replacing metal with parts molded of *four different* Durez materials. Working as a team, Westinghouse engineers and the molder, GENERAL INDUSTRIES CO., selected each of the four Durez phenolics for better performance at lower manufacturing cost on the job it must do.

To save time in capitalizing on the versatility of Durez, talk over your design problems first with your molder. Or call on our Technical Field Service in putting its mechanical, electrical, and chemical properties to profitable use.

DUREZ®

Phenolic Plastics that fit the job

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

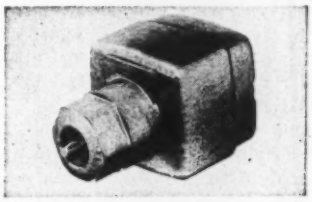
510 Walck Road, North Tonawanda, N. Y.

HOOKER CHEMICALS PLASTICS

**Laundromat* ® *by Westinghouse Electric Corp.*

New Parts

gives extremely long life under continuous operation. No brushes, slip rings or other parts that need regular maintenance or replacement are used. Double-pole double-throw switch with capacitor senses speed



when takeoff shaft rotates in either direction. A current which is exactly linear to speed is transmitted to centrally located indicator up to 1000 ft. away. Very little operating torque is required. Either of two stainless-steel keyed shafts are standard, with 5/16-in. round and ¼-in. square also available. **Metron Instrument Co.**, 432 Lincoln St., Denver 9, Colo.

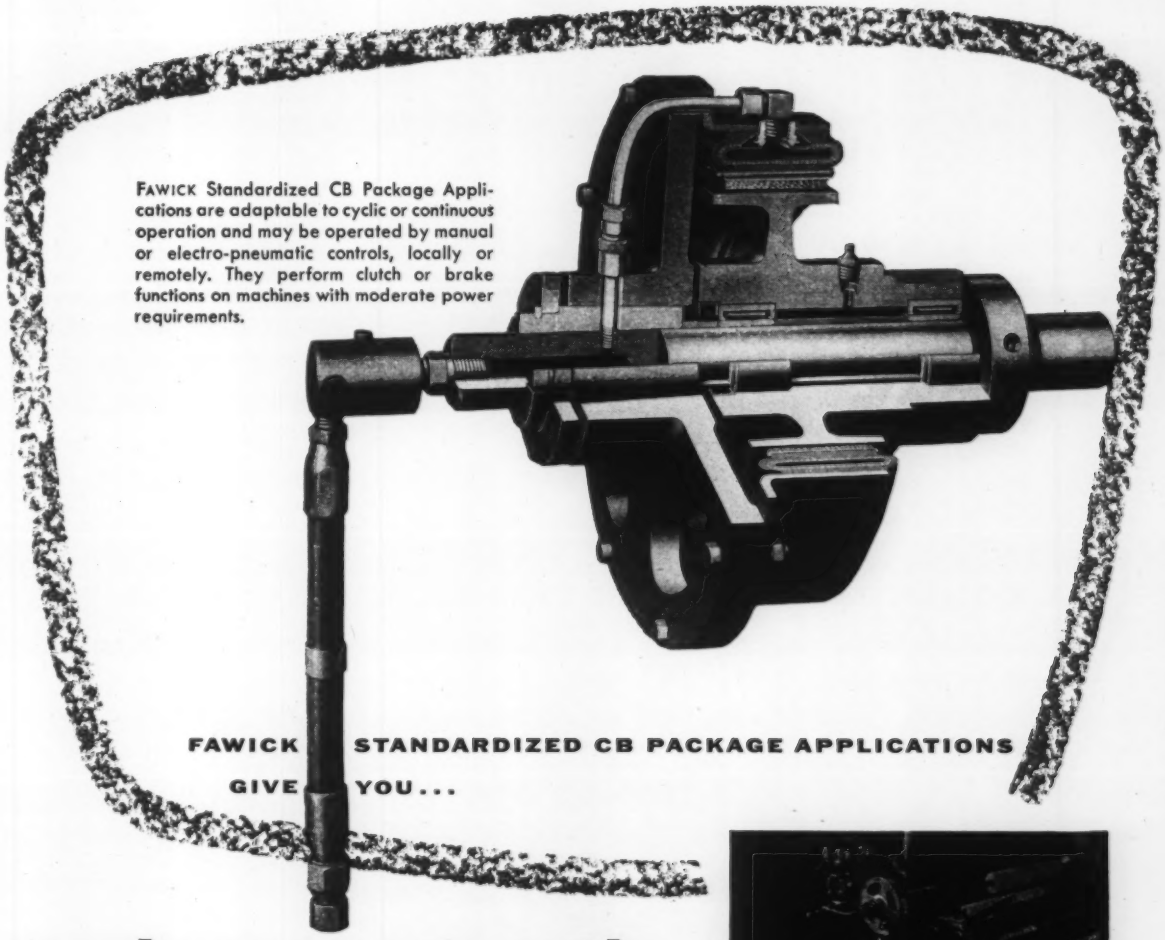
Circle 474 on page 19

Automatic Valve

for gas lines has fast closing and slow opening

Automatic gas valve is fast closing and slow opening unit for use with flame safeguard system. Motor-operated valve has powerful compression spring to shut off fuel flow in 0.8 sec. Heavy-duty electric drive unit controls rate of opening to reach 75 per cent maximum flow in six seconds. Position indicating

switch performs as safety interlock. If, prior to light-off of burner, valve is slightly open, switch will not allow light-off to take place. Electric circuit to burner control remains off until valve is completely closed. In case of flame failure or loss of electric power, valve closes when tripped automatically by either of two independent releases. Shearing action by valve



FAWICK Standardized CB Package Applications are adaptable to cyclic or continuous operation and may be operated by manual or electro-pneumatic controls, locally or remotely. They perform clutch or brake functions on machines with moderate power requirements.

FAWICK STANDARDIZED CB PACKAGE APPLICATIONS GIVE YOU...

modern pneumatic power transmission at low cost

Conversion of your machinery to modern air operation is a simple matter when you use FAWICK Standardized CB Package Applications. The packages are complete and ready-to-install. They include a FAWICK CB Airflex Clutch, FAWICK Rotorseal, drum and mounting components. Tapered bushing construction provides standardized bore sizes for easy installation. Where application is necessary, anti-friction bearings are used as illustrated above. Three basic designs are available: spider bearing mounted, gap mounted or close mounted.

The price is low! Volume production of these FAWICK units and availability as "off the shelf" items eliminate costly custom engineering and assure speedy delivery. Consult your nearest FAWICK Representative or the Home Office for more information. Ask for Bulletin ML-173.

The B. F. Goodrich Company uses Standardized CB Package Applications for power transmission on this Sheet Stock Packing Machine. The clutches also perform slip clutch and tension brake functions during winding and unwinding operations. Sensitive response to controls permits close adjustment of tension and slip. The low-maintenance feature reduces machine down-time.

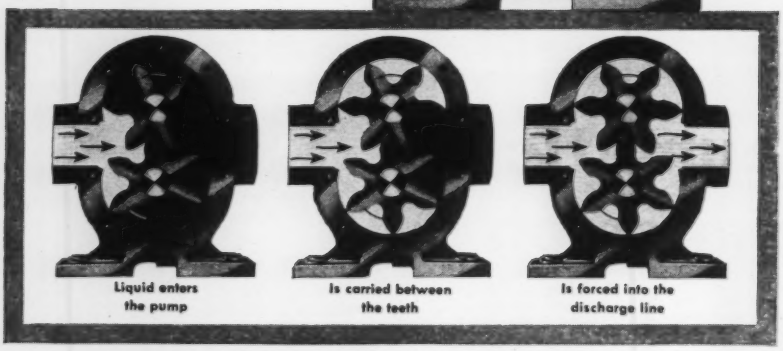
FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
In Canada: Fawick Canada, Ltd., Toronto, Montreal

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

Circle 602 on page 19

IF
"THE PRINCIPLE OF THE THING"
MEANS ANYTHING TO YOU
then look to ROPER

only 2 moving parts
HELP MAKE
ROPERS
DEPENDABLE



SMOOTH AND QUIET FLOW...
EQUAL EFFICIENCY IN EITHER DIRECTION

HOW IT OPERATES — The unmeshing of the gears produces a vacuum, drawing the liquid into the tooth spaces. The liquid is carried between the teeth and case to the opposite side of the pump. The meshing of the gears forces the liquid into the discharge line. This is a positive displacement pump. The Roper principle is simple in design. It has only two moving parts — equal size pumping gears — operating in a case with proper amount of clearance to promote high efficiency and long life.

GEO. D. ROPER CORPORATION 250 Blackhawk Park Ave., Rockford, Ill.

Send for helpful handbook
"HOW TO SOLVE PUMPING PROBLEMS"

ROPER
Rotary Pumps

Circle 603 on page 19

New Parts

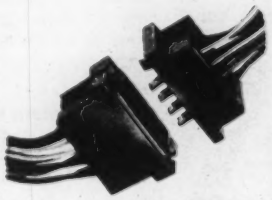
disk cuts through dirt or scale on valve seat. Valve is available in sizes from 1 to 6 in. **Electronics Corp. of America,** Combustion Control Div., 77 Broadway, Cambridge 42, Mass.

Circle 475 on page 19

Plug and Receptacle

eliminate soldering of connections

Economical plug and receptacle units have crimped terminals for snap-in assembly to eliminate soldering. Molded from material which provides good electrical and physical properties, terminal blocks

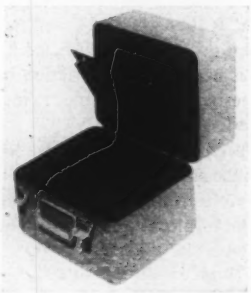


have high dimensional stability and low moisture absorption. Terminals are available individually or in reels for automatic machine assembly to wires. Rating is up to 15 amps. Application of the units is for fast, simple assembly in major appliances, electronics, machinery, or other devices requiring multiple circuit hookups. **Molex Products Co.,** 9515 Southview Ave., Brookfield, Ill.

Circle 476 on page 19

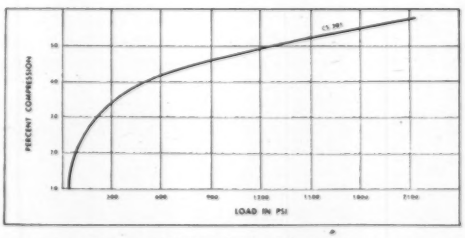
Instrument Cases

are available in 3 styles



Standard line of drawn aluminum instrument cases, complying with military specifications, is available in transit, combination, and

Accopac® fiber gasket seals tightly under stamped flanges

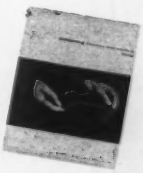


HIGH COMPRESSIBILITY of CS-301 Accopac is shown by load-compression curve. With light metal flanges, this compressibility allows gaskets to conform to surface irregularities and form a tight seal without distorting flange.

Armstrong CS-301 Accopac® is a highly compressible fiber gasket material that forms a tight seal against fluids even under the low bolting pressures available with stamped flanges.

CS-301 is made by a patented beater saturation process that locks cellulose fibers and cork in a non-extractable latex binder. The cork—thousands of tiny, springy particles—gives CS-301 its high, uniform compressibility. And although CS-301 is unusually compressible, it retains bolt torque well at flange pressures under 2000 psi at temperatures up to 200° F.

CS-301 is a dependable seal for water, air, most gases, and many commonly used solvents. It is now being used for many applications in automobiles, tractors, appliances, and industrial equipment.



For more information about Armstrong CS-301 Accopac, write Armstrong Cork Company, 7010 Dean Street, Lancaster, Pennsylvania.

Armstrong ACCOPAC

. . . used wherever performance counts

Circle 604 on page 19

New trends and developments in designing electrical products . . .

How to magnetize permanent magnets to obtain maximum energy product and magnetic stability

According to the domain theory of ferromagnetism, a magnetic material is composed of elementary magnetic volumes called domains. These domains are randomly oriented in unmagnetized materials (Figure 1). Their fields cancel each other, and no external field results.

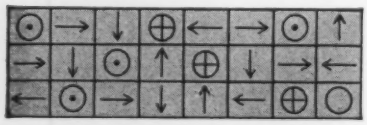


Figure 1—Demagnetized material (domains completely disorganized)

Subjecting the magnetic material to an external field rotates the elementary magnets in the direction of the applied field (Figure 2). In permanent magnets, this orientation is retained to some extent after the field is removed. The magnetic material exhibits poles and an external field.

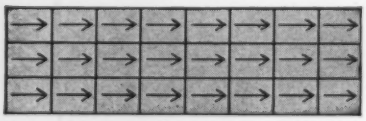


Figure 2—Magnetized material (domains rotated into alignment)

The improvement of permanent-magnet materials has made the elementary domains more difficult to align. Proper magnetization techniques have thus become highly important because of the adverse results of partially magnetized magnets.

Partial magnetization means that the full external field capabilities of the magnet are not realized. And, the magnet is less resistant to demagnetizing influences – hence less stable.

Consequently, General Electric has done extensive work with users of permanent magnets on the problems of effective magnetization.

Modern magnetizing equipment takes advantage of the fact that magnetization is essentially an instantaneous process, and may be achieved with short-duration current impulses. Consequently, direct-current equipment, like generators and electromagnets, are giving way to impulse equipment.

The main advantages of impulse-type magnetizers are lower equipment cost, reduced demand on power supply, and greater flexibility in shapes of fields that can be set up. Impulse equipment generally falls into two basic types:

(1) Half-cycle type, operating from A.C. line (Figure 3). Here, an ignitron tube with suitable control allows current to flow for one-half cycle.

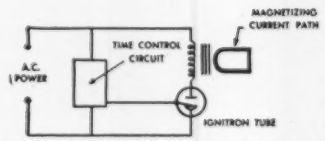


Figure 3—Circuit for half-cycle-type magnetizer

(2) Energy-storage type (Figure 4). Here, a capacitor is charged at a relatively slow rate, and then discharged into the magnetizing circuit. This type of equipment is extremely versatile; tremendous peak currents are possible from low-capacity power systems.

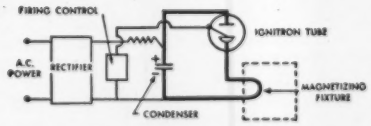
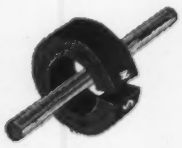


Figure 4—Circuit for energy-storage-type magnetizer

Using this equipment, a simple magnet shape like the "C" magnet in Figure 5 can be magnetized by a single conductor threading the magnet.

Figure 5—Conductor arrangement for "C" magnet



The "E" shape configuration (Figure 6) uses two conductors arranged to carry current in opposite directions to achieve correct polarity.

Figure 6—Conductor arrangement for "E" magnet

Multi-pole magnets (Figure 7) require alternate conductors carrying current in opposite directions to establish simultaneous magnetization of all poles.

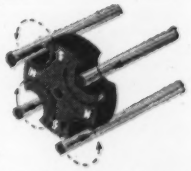


Figure 7—Conductor arrangement for multi-pole magnet

One of the more recent developments in magnet configurations – the "bowl" magnet – can be magnetized radially by the conductor arrangement in Figure 8.

Figure 8—Conductor arrangement for "bowl" magnet

These examples give some idea of the variety of magnetizing problems encountered by users of permanent magnets. Each configuration represents a distinct engineering problem in which such variables as conductor size, conductor arrangement, peak current, and current duration must be accurately balanced.

General Electric magnet engineers have at their fingertips all the knowledge and techniques requisite for efficient magnetization. They are always ready to assist designers and users of permanent magnets in getting maximum-energy product and stability.

For more information on G-E Alnico magnets, or assistance on any phase of your magnet design problem, write *Metallurgical Products Department of General Electric Company, 11126 E. 8 Mile Ave., Detroit 32, Michigan.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

instrument case types. All cases are waterproof, and both transit and combination type cases are equipped with carrying handle and spring-loaded latches. Sizes of case illustrated range from 8 by 11 by 5½ in. to 15⅝ by 19⅛ by 11½ in. in metal thicknesses of 0.064-in. to 0.091-in. Case accommodates panel sizes of 6 15/16 by 9 15/16 in. to 14½ by 18 in. **Instrument Cases Inc.**, 510 Garfield St., Glendale 4, Calif.

Circle 477 on page 19

Floodlight

for high-vibration applications

Heavy-duty floodlight for heavy industrial applications involving vibration, has all-steel base with 2½ in. diam coil spring to absorb lateral and vertical vibration. A

second shock absorbing spring is mounted directly behind the sealed beam lamp which is protected by an aluminum housing. Four 120-v models and a 28 v model are available. Applications are on earth-moving equipment, tractors, trucks, cranes, etc. **A & A Mfg. Co. Inc.**, 2017 W. Clybourn St., Milwaukee 3, Wis.

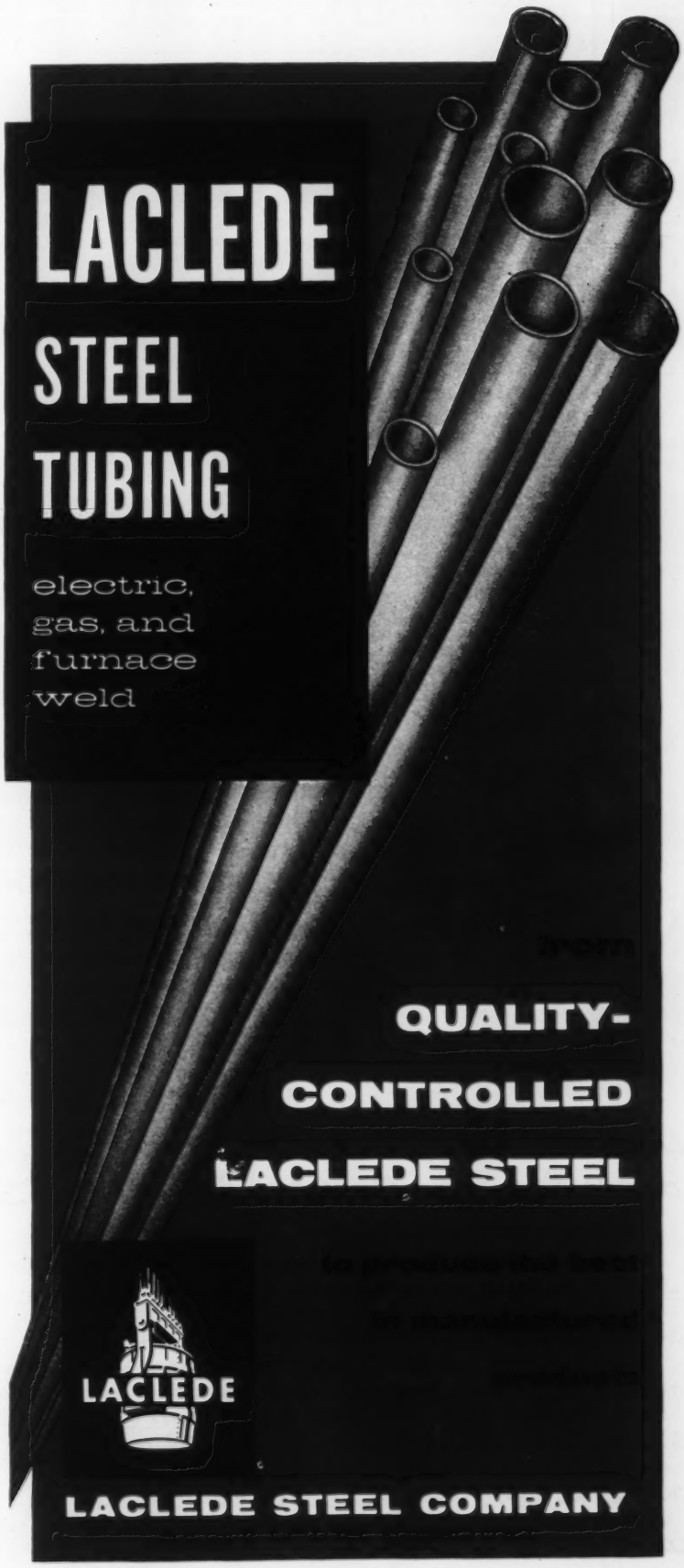
Circle 478 on page 19

Motor-Mount Cleat

for synchro-groove or clamp ring units

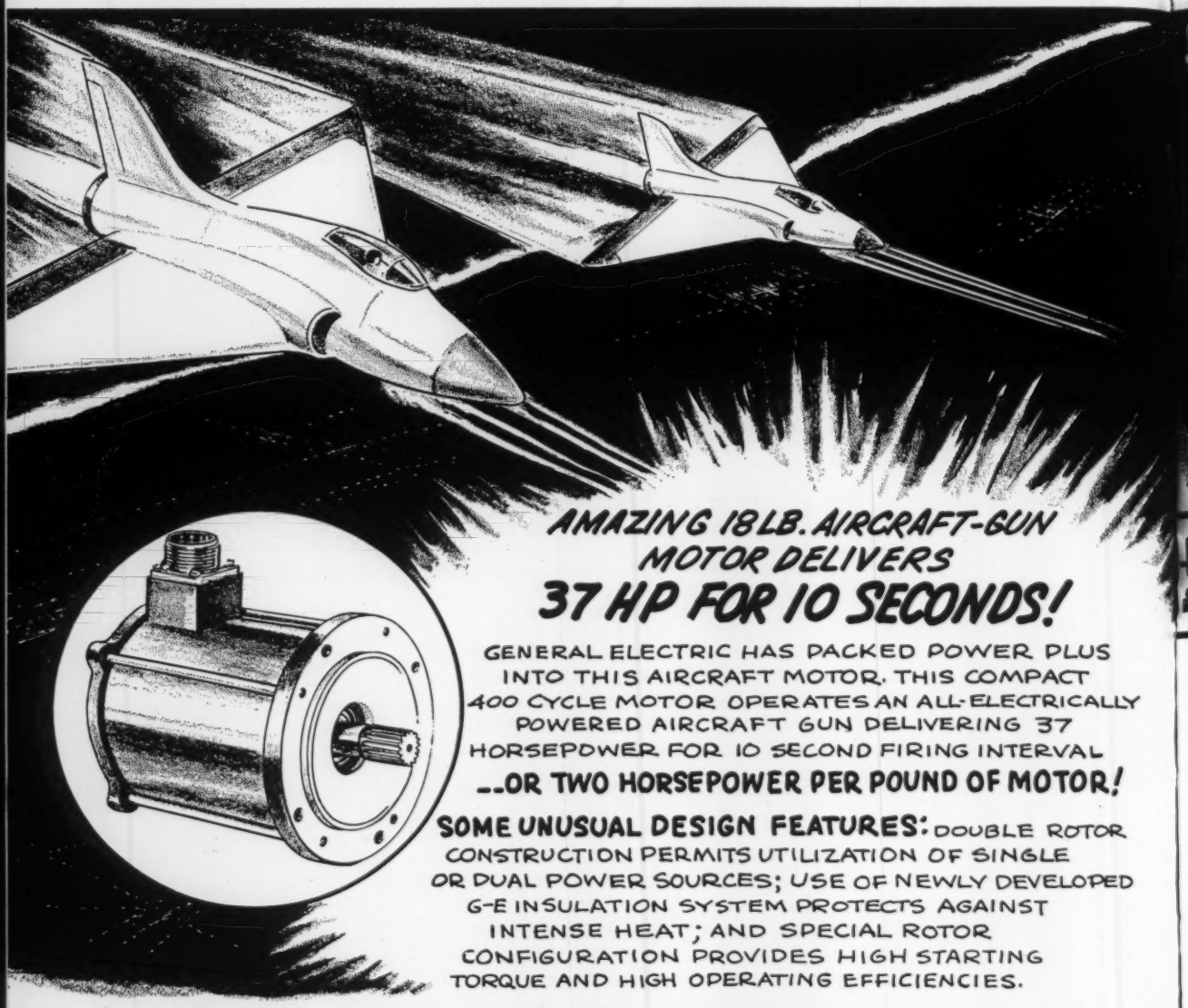
Type L2 motor mounting cleats are available from stock in four different heights. Made of No. 303 stainless steel, mounts are clear passivated to meet military specifications. Applications are for any syncro, potentiometer motor, resolver, autosyn generator, or other

(*Continued on Page* 189)



Circle 606 on page 19

DESIGN SOLUTIONS with G-E



AMAZING 18 LB. AIRCRAFT-GUN MOTOR DELIVERS 37 HP FOR 10 SECONDS!

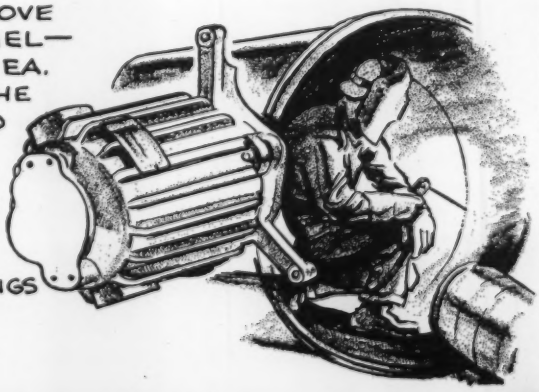
GENERAL ELECTRIC HAS PACKED POWER PLUS INTO THIS AIRCRAFT MOTOR. THIS COMPACT 400 CYCLE MOTOR OPERATES AN ALL-ELECTRICALLY POWERED AIRCRAFT GUN DELIVERING 37 HORSEPOWER FOR 10 SECOND FIRING INTERVAL

--OR TWO HORSEPOWER PER POUND OF MOTOR!

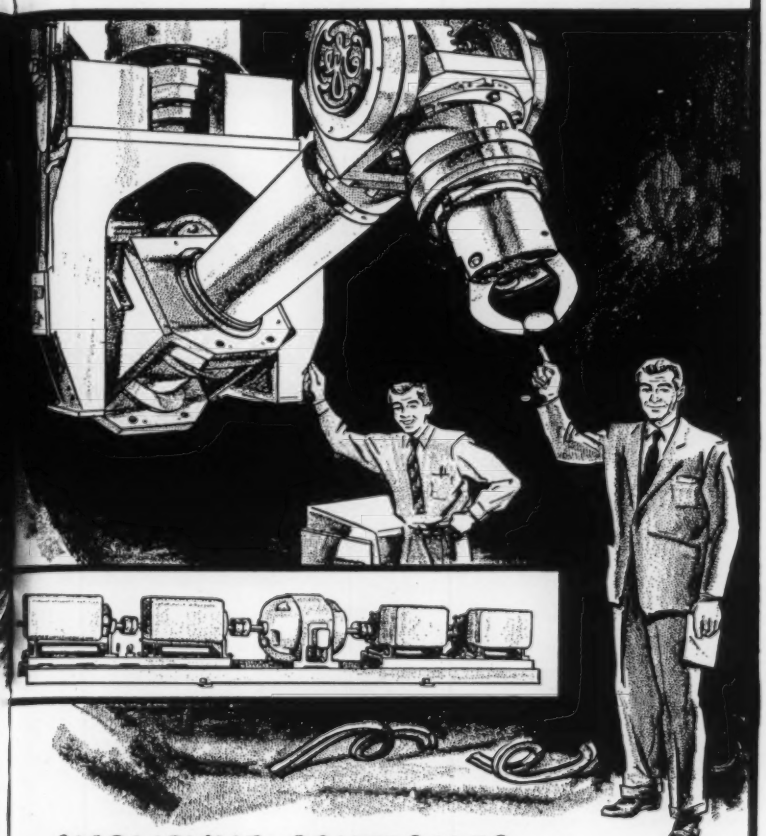
SOME UNUSUAL DESIGN FEATURES: DOUBLE ROTOR CONSTRUCTION PERMITS UTILIZATION OF SINGLE OR DUAL POWER SOURCES; USE OF NEWLY DEVELOPED G-E INSULATION SYSTEM PROTECTS AGAINST INTENSE HEAT; AND SPECIAL ROTOR CONFIGURATION PROVIDES HIGH STARTING TORQUE AND HIGH OPERATING EFFICIENCIES.

THIS SPECIALLY COOLED G-E MOTOR OPERATES WHERE DEPENDABILITY CAN MEAN LIFE ITSELF!

THIS G-E MOTOR DRIVES A VENTILATOR TO EXHAUST WELDING FUMES WHICH CAN PROVE DEADLY IN THIS UNDERGROUND CABLE TUNNEL— OR IN A SHIP'S HOLD OR ANY ENCLOSED AREA. DEPENDABILITY IS IMPERATIVE. DESIGN OF THE TOTALLY-ENCLOSED MOTOR (TO BE MOUNTED INSIDE BLOWER) POSED THE PROBLEM OF DISSIPATING MOTOR HEAT. G-E ENGINEERS SOLVED THE PROBLEM BY BUILDING THE MOTOR WITH SPECIAL HEAT-DISSIPATING RIBS. AN INTERNAL FAN TRANSFERS HEAT FROM THE WINDINGS WHILE THE BLOWER ITSELF BRINGS COOLING AIR OVER THE RIBBED HOUSING.



specialty motors



AMPLIDYNE-CONTROLLED MECHANICAL ARM HAS FINGERS THAT TWIST STEEL OR HANDLE AN EGG

A G-E MULTIPLE AMPLIDYNE SET CONTROLS THE MUSCLES OF O'MAN, AN OVERHEAD MANIPULATOR BUILT BY GENERAL ELECTRIC. O'MAN CAN KNOT STEEL BARS, YET DEMONSTRATES A DELICATE TOUCH WHEN IT LIFTS AN EGG WITHOUT BREAKING IT. O'MAN IS THE WORLD'S LARGEST MECHANICAL ARM BUILT TO SUBSTITUTE FOR HUMAN BRAWN IN RADIO-ACTIVE AREAS.

A SYSTEM CONSISTING OF G-E DEVELOPED AMPLIDYNES PROVIDES 20 TO 1 SPEED CONTROL, DYNAMIC BRAKING, CURRENT LIMIT OVERLOAD PROTECTION, AND ADEQUATE AMPLIFICATION TO KEEP CONTROLLER SMALL.

AVAILABLE: COMPLETE SMALL MOTOR ENGINEERING ASSISTANCE FOR YOU!

HERE'S THE SPECIAL ATTENTION YOUR SMALL MOTOR PROBLEMS GET AT G-E.

1

YOUR LOCAL G-E APPARATUS SALES ENGINEER LEARNS ALL ABOUT YOUR MOTOR NEEDS.

2

HE CALLS A TEAM OF FACTORY ENGINEERS WITH YEARS OF MOTOR APPLICATION EXPERIENCE.

3

AT THEIR DISPOSAL ARE G.E.'S COMPLETE DEVELOPMENT AND TESTING FACILITIES.

4

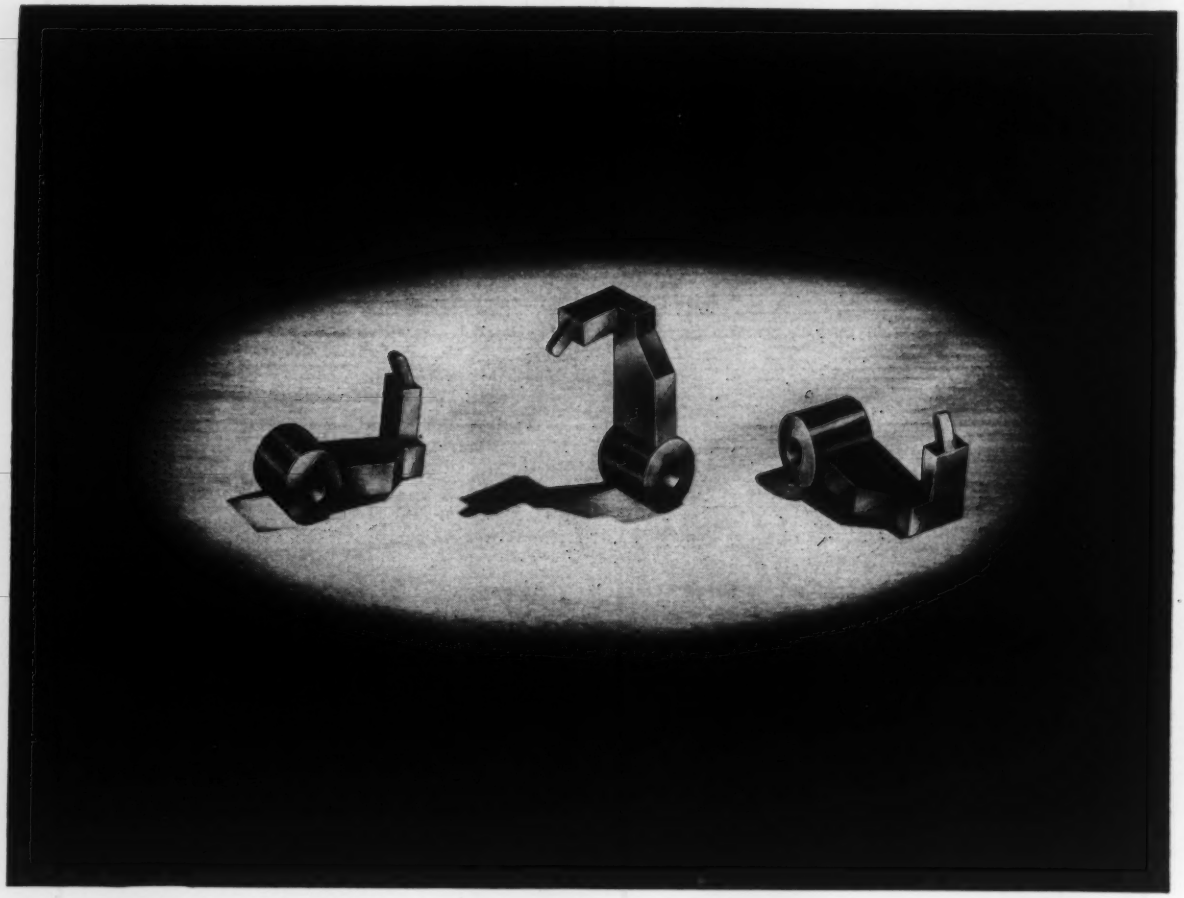
IN SHORT ORDER A SAMPLE G-E MOTOR IS READY FOR TESTING ON YOUR PRODUCTS.

FOR THIS COMPLETE HELP, CONTACT YOUR NEARBY G-E APPARATUS SALES OFFICE.

WRITE FOR MORE INFORMATION COVERING G-E EQUIPMENT DESCRIBED IN THIS AD TO GENERAL ELECTRIC CO., SECT. 633-3, SCHENECTADY 5, N.Y.

GENERAL ELECTRIC

Circle 607 on page 19



Impossible in Powdered Metal? Not at PARKER

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Edward F. Higgins, Jr. • 102 West Adams Street

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This part—with projections in several planes, not to mention an I.D.-O.D. section—looked like an impossible job for powdered metal. Yet Parker made it in **one press operation**—complete—to close tolerances and tight "specs"—at relatively **low cost.**

This unusual piece points up the advantages offered by Parker powdered metal processing. Tough cost problems of conventional casting and machining methods often can be solved. Tensile strength, ductility and impact resistance can be closely controlled to meet rigid specifications. Powdered metal constituents can be precisely and uniformly blended for a wide range of requirements.

Parker's experience and facilities in producing a wide variety of powdered metal parts have saved money—and solved problems—for many users. Your problem may be one that Parker can solve in like manner. Just call the nearest Parker sales engineer listed at the left.

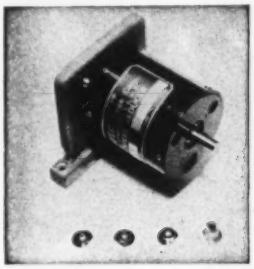
Parker White Metal Company • 2153 McKinley Ave., Erie, Pa.

PARKER

POWDERED METAL PARTS
ALUMINUM and ZINC
die castings

Circle 608 on page 19

(Continued from Page 185)



rotating component which has standard syncro-groove mounting or clamping ring. **PIC Design Corp.**, P. O. Box C, East Rockaway, L. I., N. Y.

Circle 479 on page 19

Potentiometer

with air-core or mandrel winding

Series 7700 precision potentiometer is a 10-turn unit for servo or three-hole pilot mounting. Air core windings have total resistance range from 200 to 5000 ohms and negligible phase shift in ac circuitry (less than 0.1-deg). Linearity of air-core wound units approaches resolution of unit with-

out padding or shunting because resistance element is servo-wound directly on potentiometer drum. Copper-mandrel wound units are available with total resistances from 5000 to 200,000 ohms. **Helipot Corp.**, Newport Beach, Calif.

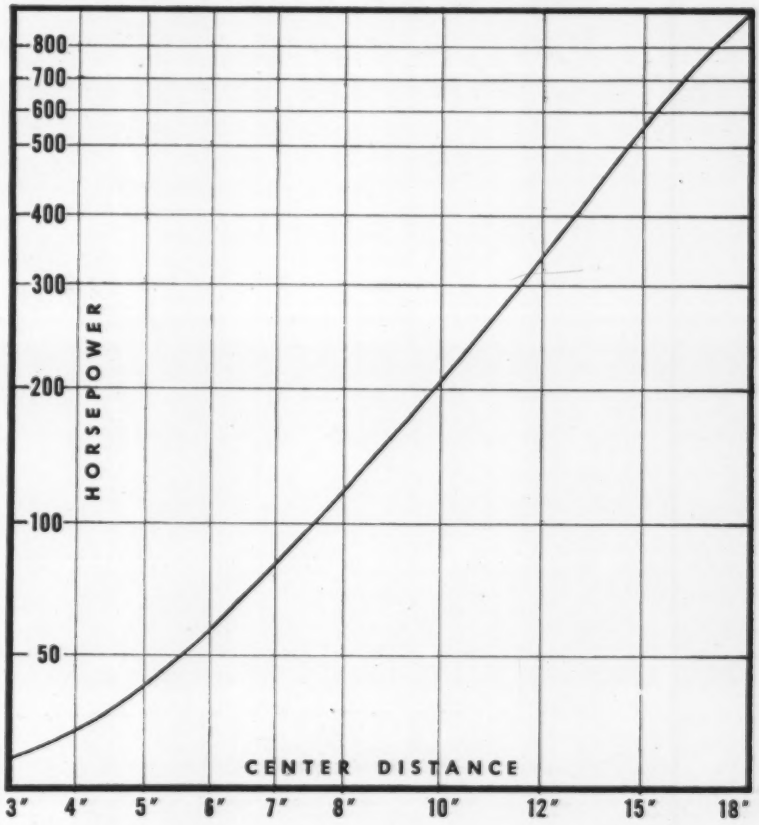
Circle 480 on page 19

Core Laminations

have high permeability

Four nickel-iron standard laminations are known as UI-312, F-21, DU-1, and DU-37. Laminations are made on tungsten-carbide dies and are ground to make them burr-free and flat for precision

"DO-IT-YOURSELF"



Prove the difference in worm gear speed reducers yourself. Here's how . . .

. . . On this chart we've plotted the mechanical horsepower capacity of Cone-Drive worm gear speed reducers against their center distances. Ratings are for Class I Service with a 5:1 reduction and an input speed of 1750 rpm.

All you have to do is plot the corresponding ratings for the speed reducers you're now using or planning to use. We think you'll be surprised at the results.*

For details on Cone-Drive gearing's double-enveloping design and specifications, ask for Bulletin 600C. We'll send it to you immediately without obligation.

*If you're too busy to "Do-it-yourself", Cone-Drive representatives will be glad to show you filled-in charts.

CONE-DRIVE GEARS
Division Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

Circle 609 on page 19

New AIRCOMATIC® HEAD for better machine welding

New AMH-B Head welding cylindrical containers on a high production basis. All components of this Aircomatic package — power supply, inert gases, and Aircomatic welding wire — are available from Airco.

The new improved Airco AMH-B Aircomatic Head has been developed for the fabrication of ferrous and nonferrous metals on a high production basis. Used in conjunction with constant arc voltage power supply, this unit provides automatic control of the arc voltage. Standard shielding gases—argon, helium, mixtures (AG75) and CO_2 — are used. Advantages of the AMH-B include: two speed ranges, up to 900 inches per minute high range, and up to 600 inches per minute low range; all types of Aircomatic welding wire, from .030" to 3/32" diameters, can be used.

Wire is fed at a constant speed by an adjustable speed motor. Easy adjustment of the head allows it to be used vertically or horizontally.

For handling most applications the basic package consists of the Aircomatic unit, a machine barrel and a wire guide component kit. The basic Aircomatic unit includes the head, main control panel and remote control operator's station. For complete information write Airco direct.

AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND . . .

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AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated
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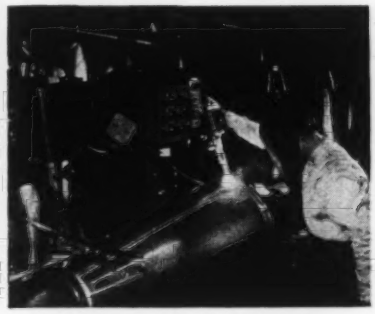
In Canada — Air Reduction Canada Limited

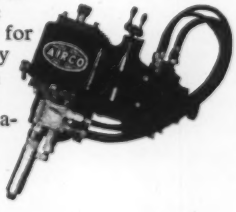
Products of the divisions of Air Reduction Company, Incorporated, include: AIRCO — industrial gases, welding and cutting equipment, and acetylenic chemicals • PURECO — carbon dioxide, liquid-solid ("DRY-ICE") • OHIO — medical gases and hospital equipment • NATIONAL CARBIDE — pipeline acetylene and calcium carbide • COLTON — polyvinyl acetates, alcohols, and other synthetic resins.



Note these outstanding advantages of the new AMH-B

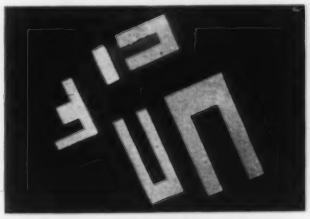
- Accommodates wide range of metal thicknesses — take fine wires (.030") for thin gauges, and up to 3/32" for normal gauges.
- Versatility — through availability of 3 machine barrels with duty ratings of 350, 500 and 600 amperes.
- Extreme compactness contributes to ease of installation, setting up, and servicing.
- Designed so that accessory equipment may be connected easily, quickly.
- Easy to mount: only standard 1½" steel pipe is required.
- Can be used with argon, helium, mixtures (AG 75) and CO_2 gases.
- Simplified design means easier maintenance and longer life.

You'll find the new AMH-B Aircomatic Head ideal for high quality welding on production type applications. For complete details



WRITE DIRECT TO

AIRCO



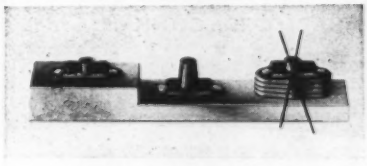
stacking. Laminations are for applications requiring high initial or high maximum permeabilities. **Magnetics Inc.**, Box 230-T, Butler, Penna.

Circle 481 on page 19

Anchor Nut

eliminates need of shims where material is thin

Deep counterbore, two-lug, floating anchor nut is designated Kaylock F1934. Unit eliminates use of shims at locations where material is thin. Developed principally for use around access doors or similar



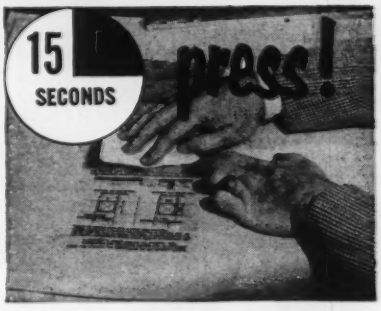
openings requiring constant grip-length screws for different thicknesses of materials, nut may be used wherever a long screw is required. Fastener is available in a wide range of sizes and finishes. **Kaynar Co.**, Keylock Div., Box 2001, Terminal Annex, Los Angeles 54, Calif.

Circle 482 on page 19

Subminiature Amplifier

in both transistor and vacuum tube models

Designed to operate at high efficiency and to occupy minimum space, subminiature servo amplifier is available in both transistor and vacuum-tube types. Transistor models include 1-w and 3-w units using silicon transistors for use in a wide range of environments, and 6-w and 9-w units using germanium transistors to provide high power output. Units are designed for use with 400-cps servo-motors in airborne service and vary in



it's that simple!

Draftsmen want to use STANPAT in place of the old-fashioned time-consuming method of re-drawing and re-lettering specification and revision boxes, standard symbols, sub-assemblies, components, and cross sections.

STANPAT reprints your standard drawing details on acetate sheets with adhesive on front or back. Guaranteed not to dry out, come off, or wrinkle. Reproductions come crisp and clear. Save drafting time and money; use STANPAT whenever drawing details re-appear on your tracings.

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STANPAT CO., Whitestone 57, N. Y. U.S.A.
Phone: FLushing 9-1693-1611 Dept. M-10

☐ Please quote on enclosed samples
☐ Kindly send me STANPAT literature and samples

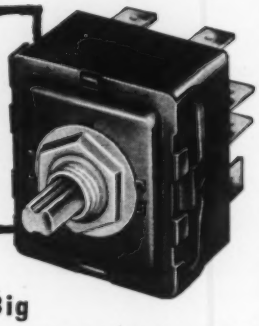
NAME _____
TITLE _____
COMPANY _____
ADDRESS _____

Circle 611 on page 19

XUM

This Little Switch Goes to Market

. . . in air conditioners, fans, unit heaters, appliances, motor and resistive circuits.



This Little Switch Is Big

Ratings range up to 25 A. at 120 or 240 V., and ½, ¾ and 1 hp at 120 V. and 2 hp at 240 V., A.C. U.L. Approved. (Small D.C. ratings also available.) *But base is only* 1½" x 1¼" x ⅛".

This Little Switch Saves Money

Costs less—permits simplification of your designs. Spindle extensible through base to permit ganging of mechanical and electrical controls . . . spade terminals for quick wiring . . . dummy terminals, if required, to eliminate need for blocks.

This Little Switch Is The NEW "Diamond H" Series 390 Rotary

. . . single or double pole, two to twelve positions with stop as required. Single, two-hole or special mounting arrangements. Completely interchangeable with the widely used "Diamond H" Series 240 switches which are still available.

Write today for complete information to meet your requirements

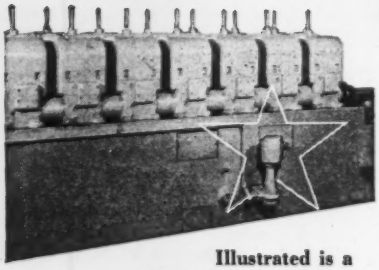
THE HART MANUFACTURING COMPANY

118 BARTHOLOMEW AVE., HARTFORD, CONN.

Circle 612 on page 19

Star Performer on METAL WORKING machinery

Ruthman Gusher Coolant Pumps



Illustrated is a Yoder Forming Mill—equipped with a Ruthman Gusher Coolant Pump.

You get instantaneous coolant flow, from trickle to full volume, the moment the machine starts, with a Gusher Coolant Pump. The electronically balanced shaft reduces wear from vibration to a minimum. The pre-lubricated ball bearings require no maintenance attention. From every angle, Ruthman Gusher Coolant Pumps are better.

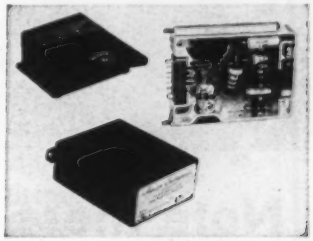
THE RUTHMAN MACHINERY CO.

1811 Reading Road **Cincinnati, Ohio**

Circle 613 on page 19

New Parts

size from 6 to 12 cu in. with weight from 4 to 5 oz. Vacuum-tube models include a 5-w amplifier,



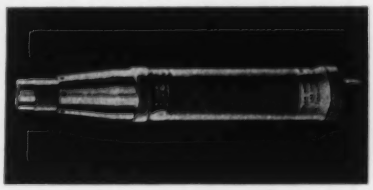
and a precision summing-amplifier handling up to 7 inputs at an accuracy of ±0.5 per cent. This model occupies 4 cu in. and weighs 4 oz. **W. L. Maxson Corp.**, Maxson Instruments Div., 47-37 Austell Place, Long Island City 1, N. Y.

Circle 483 on page 19

Liquid Spring

develops 6400 lb

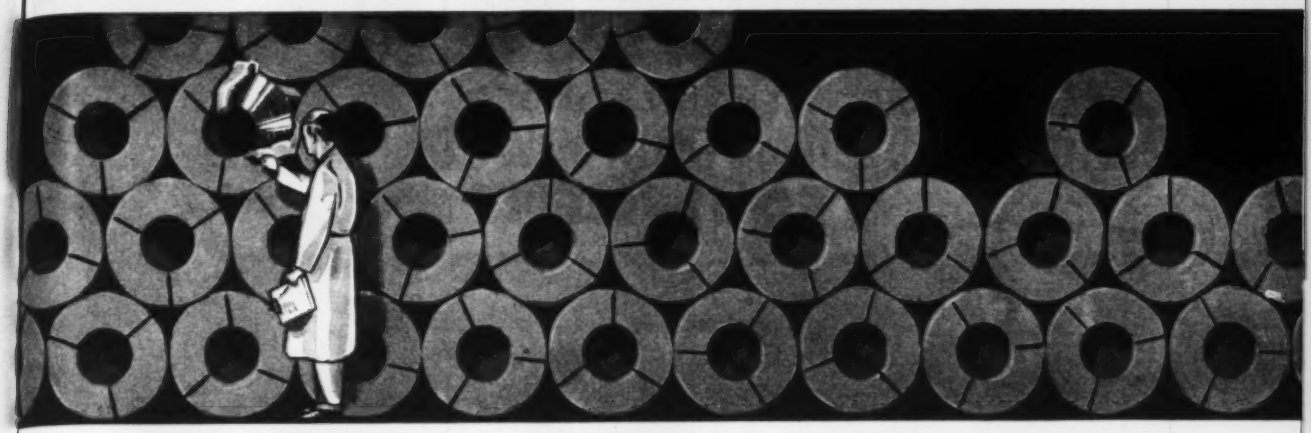
High velocity, liquid-spring shock-absorber uses liquid compressibility for high energy absorption. Self-contained unit is designed for use where energy release must be instantaneous. Ninety per cent of the ¾-in. stroke is a spring; the last ten per cent acts as a shock absorber to stop the high-velocity piston without damage. High-velocity output can be used to accelerate a mass, and high impact



cushioning action can be used to decelerate a mass without impact loading. Spring develops 6400-lb spring action on a ¾-in. stroke with a preload of 1000 lb. Unit provides 10 in.-lb of shock absorption while providing 200 in.-lb high-velocity energy output with total efficiency of 77 per cent. Shock absorber is 1¼ in. OD by 8 in. long. Each has a bearing surface to facilitate reciprocation of the spring body for designs which utilize the cylinder as a reciprocating mass. **Taylor Devices Inc.**, 188 Main St., North Tonawanda, N. Y.

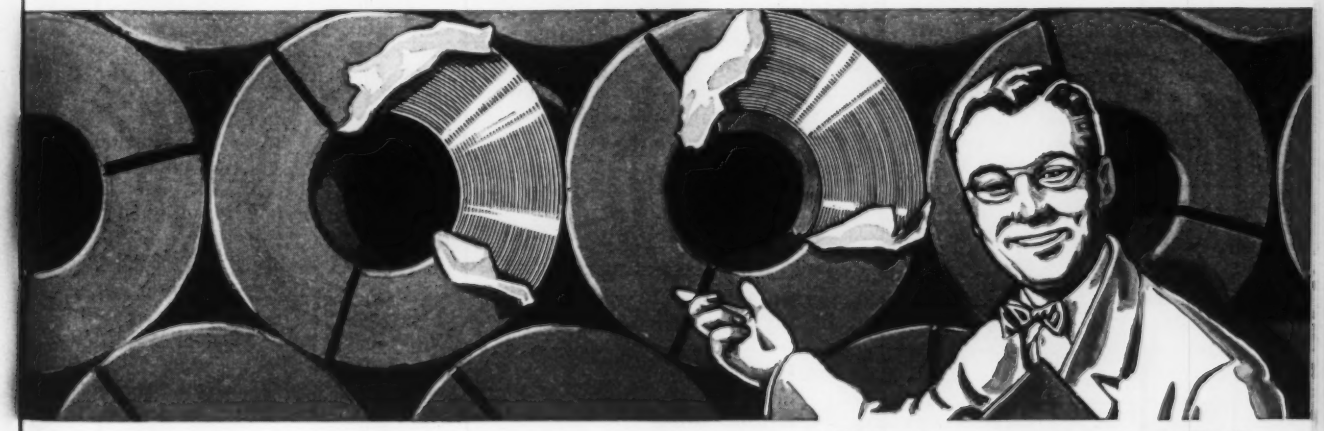
Circle 484 on page 19

Assured uniformity...



coil...

after coil...



after coil!

After the correct steel for the application has been determined the most important service a mill can render a customer is to make certain every pound of steel delivered meets specification.

The ability to assure uniformity, coil after coil, is a big reason why Sharon today is supplying more customers than at any other time in their 52-year-old history.

Circle 614 on page 19

SHARONSTEEL

SHARON STEEL CORPORATION

Sharon, Pennsylvania

DISTRICT SALES OFFICES: Chicago, Cincinnati, Cleveland, Dayton, Detroit, Grand Rapids, Indianapolis, Los Angeles, Milwaukee, New York, Philadelphia, Rochester, San Francisco, Sharon, Seattle, Montreal, Que., Toronto, Ont.

XUM

YOU WOULDN'T BUY
A HAT THAT'S TOO BIG!

SO WHY BUY A CONTROL THAT'S THE WRONG SIZE?

FURNAS
MAGNETIC CONTROLS
GIVE YOU
CORRECT CAPACITY
FOR THE JOB!

The many in-between sizes in the Furnas Electric starter line let you select the motor control that is best suited for your particular requirements—with no wasted capacity and expense. Match the starter to the job and save up to 25%. For proof, compare the 9 sizes of the Furnas Electric starter line with the 5 sizes normally offered. And you can save up to 40% in space by using the correct size starter.

For more information write for Bulletin 5530—1045 McKee Street, Batavia, Ill.

A11

FURNAS ELECTRIC COMPANY
BATAVIA, ILLINOIS
Sales Representatives in all principal cities

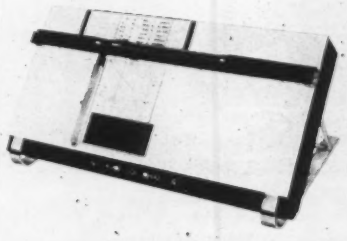
Circle 615 on page 19

ENGINEERING DEPARTMENT
EQUIPMENT

Analog Computer

performs analysis and curve fitting on plotted curves

Electrically driven analog computer performs harmonic analysis and curve fitting on plotted or recorded curves, giving reproducible results. Unit will analyze a curve in terms of a Fourier series, a power series or a least-square fit (orthogonal polynomial). Resulting equations are obtained directly from readings on machine and are recorded on a program sheet for each type of analysis. Fourier



coefficients can be determined for 48 constants and power series coefficients up to the eighth power. Least-square equations for curves fitting arbitrary test points can be obtained up to the fifth power and up to 50 equally spaced points. Instrument will handle a maximum vertical amplitude up to 10 in. and horizontal span (period) of 15 in. with a 1-in. variable reference line. **Gerber Scientific Instrument Co.**, 162 State St., Hartford 3, Conn.

Circle 485 on page 19

Adjustable Lamp

swings through 90-in. diam circle

Double-arm adjustable lamp maintains balance between moving arms permitting lamp to be moved readily. Angle of lamp may be adjusted independently of position of arms. Arms extend to 45 in. radius, rotate through 360 deg. A

New Solutions to Design Problems:

MACHINED CARBON PARTS BY Speer

If you are designing new products ... or are searching for a more efficient material for existing products ...consider carbon parts—machined by Speer.

Versatile and economical ... carbon products machined by Speer range from feather-light resistors to 1300-pound electrodes.

Speer carbon may help you improve product performance ... reduce unit costs. Write today for full details.

Carbon Is Versatile!

Can be:	Has:
Sawed	High corrosion resistance
Drilled	High heat transfer
Milled	Low electrical resistance
Broached	High thermal shock resistance
Turned	
Planed	High heat transfer (graphite)
Hobbed	
Ground	Is:
Molded	Non-warping
Extruded	Non wetted by molten metals
	Chemically inert
	Self-lubricating (graphite)

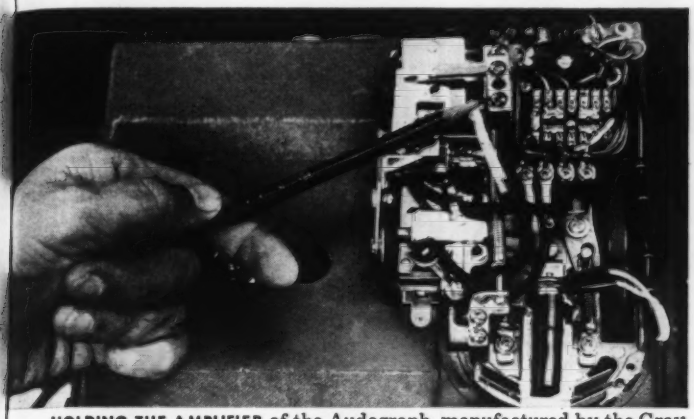
SPEER Carbon Co.
St. Marys, Pennsylvania

Divisions
Speer Resistor • Jeffers Electronics
International Graphite & Electrode

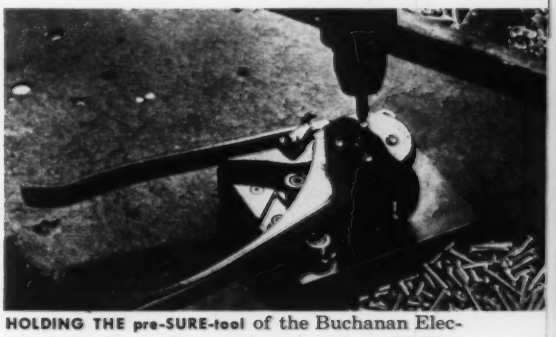
Circle 616 on page 19

PHILLIPS CROSS RECESSED HEAD SCREWS

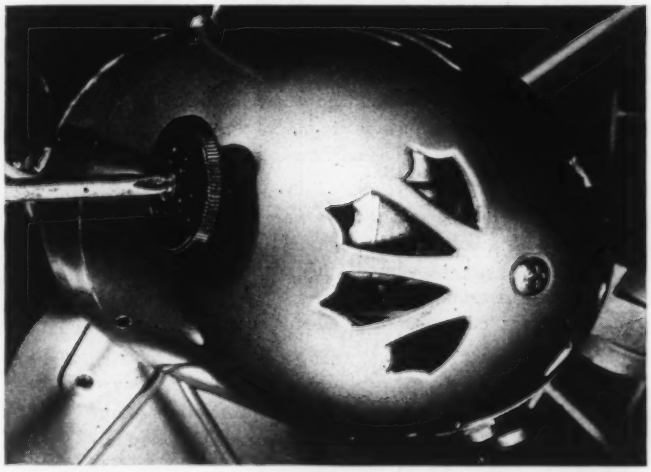
are holding down many important jobs



HOLDING THE AMPLIFIER of the Audograph, manufactured by the Gray Manufacturing Company, there are Phillips screws. Mr. William Sherman, Director of Sales, says, "Phillips screws enable us to meet the rugged performance standards required of the Audograph machine and to meet our competition in the dictation field."



HOLDING THE pre-SURE-tool of the Buchanan Electrical Products Corporation, are four Phillips screws. "By switching to Phillips screws we accelerated production, prevented driver slippage, increased the torque applied to each screw and eliminated the unattractive 'chewed up' screw head," says Mr. Mittleman, Plant Superintendent and Production Manager.



HOLDING THE OSCILLATOR KNOB as well as the fan head cover of the Fasco Industries, Inc., fans, you'll find Phillips screws. Mr. Weiland, Assistant Purchasing Agent of the company says, "When we introduced Phillips screws, we immediately improved assembly. They also eliminated burring and improved the appearance of Fasco fans."

MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY...
AND OF THE FUTURE
X marks the spot
the mark of extra quality

Pledged to highest standards...

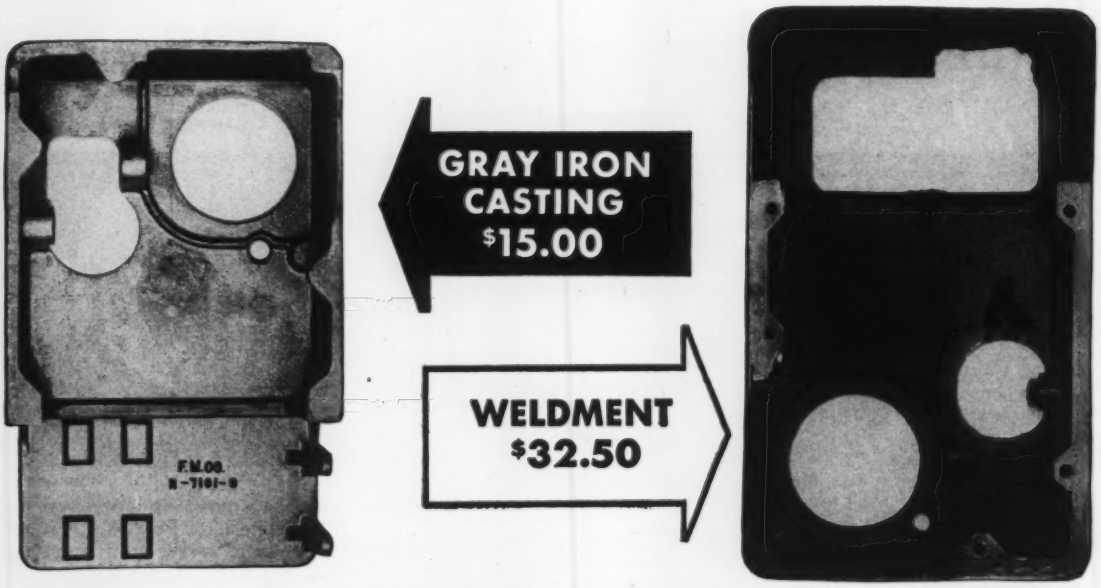
The Phillips Screw manufacturers listed here cooperate to turn out a uniformly high standard of quality. As sponsors of the Phillips Cross-Recessed-Head Standards Committee they adhere to the established dimensional standards, gauges, and gauging methods which will best serve industry.

Members of Screw Research Association

American Screw Company • Atlantic Screw Works, Inc. • The Blake & Johnson Co. • Central Screw Company • Continental Screw Co. Elco Tool and Screw Corporation • Great Lakes Screw Corp. • The H. M. Harper Company • The Lamson & Sessions Company • National Lock Company • The National Screw & Manufacturing Company • Parker-Kalon Division, General American Transportation Corporation Pheoll Manufacturing Co. • Scovill Manufacturing Company • Shakeproof Division Illinois Tool Works • The Southington Hdwe. Mfg. Company • Sterling Bolt Company • Universal Screw Company • Wales-Beech Corporation

Circle 617 on page 19

Case History No. 36 • SPLASH TRAY



Pilot-Model Weldment points way to 53% SAVING IN GRAY IRON

This symbol assures you the most for your casting dollar

Here's why it pays to call in one of the more than 500 leading foundries displaying the Society symbol:

- The most recent technical and business information is available to each member through the Society to help you design better products at lower cost.
- The use of sound cost accounting procedures is recommended and encouraged among Society member foundries, assuring full value for your casting dollar.
- Improved castings result from the advanced techniques and the high sense of responsibility of Society members.

MAKE IT BETTER WITH GRAY IRON

Admittedly, it's sometimes desirable to make pilot models by welded fabrication. However, when the model proves itself and is ready for production, you can usually make important savings by using *Gray Iron castings.*

In the above case, these splash trays were being fabricated and assembled with a bolted-on motor mounting bracket. Then Gray Iron castings were specified, and *savings amounted to $17.50 per tray!* The casting added desired rigidity, dampened vibration and provided more than adequate strength. Also, the motor mount—cast integrally—eliminated an assembly operation.

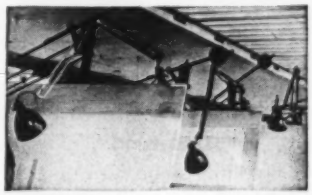
Perhaps there are examples in your own production setup where conversion to Gray Iron from a fabricated pilot model has been overlooked. Look at that part again, and consider the savings and other advantages to be gained by *casting* it in Gray Iron.

Write to the Society for technical answers to such questions, or for business information regarding castings. The Gray Iron Founders' Society, Inc., National City—East 6th Building, Cleveland 14, Ohio.

GRAY IRON FOUNDERS' SOCIETY

Circle 618 on page 19

large variety of mounting brackets is available for desk or wall use. Units are available with both in-



candescent and fluorescent lights. **Luxo Lamp Corp.**, 464 Bryant St., San Francisco 7, Calif.

Circle 486 on page 19

Force Transducers

measure forces of 10 to 100,000 lb.

Combining the proving-ring and differential-transformer principles, this transducer provides an electrical output voltage precisely proportional to applied force and exhibits exceptional stability of calibration. Available in eleven mod-

els with ranges from ±10 lb to ±100,000 lb, units are accurate to 0.5 per cent. Excitation frequency range is 60 to 10,000 cps. Maximum sensitivity is 40 mv per v at rated load. Mechanical zero adjustment is provided to null tare loads. **Daytronic Corp.**, 216 S. Main St., Dayton 2, Ohio.

Circle 487 on page 19

Accelerometers

for measuring vibration is extremely sensitive

These accelerometers are stiffness-controlled units suited for making vibration measurements over a wide frequency range. They reveal high order harmonic components of vibration. There is no

(*Continued on Page* 200)

★ Model 1AM ★ Model 2AM ★ Model 4AM ★ Model 6AM ★ Model 8AM

GAST rotary vane AIR MOTORS

offer explosion-proof, variable-speed power that's surprisingly compact!

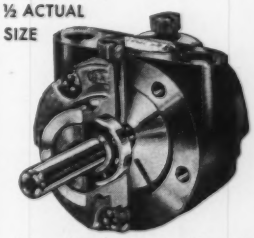
Here's the complete 5-star line of Gast rotary-vane Air Motors . . . offering ten unique advantages on products or applications located near a compressed air source:

1. Explosion-proof power in explosive or inflammable atmospheres. No sparks, no danger!
2. Low initial cost compared to other motors.
3. Variable in speed with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on 4AM and 8AM.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly compact and light for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

As original equipment, Gast Air Motors are driving pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, thread spooling machines and many other products. Right or left rotation available. Housings available with or without foot on most models.

GAST MANUFACTURING CORP.,
P. O. Box 117-P, Benton Harbor, Mich.

MODEL 1 AM
½ ACTUAL SIZE



Note the simple principle and trouble-free construction.

PERFORMANCE TABLE				
Model No.	R.P.M.	HORSE POWER at 60 P.S.I.	at 90 P.S.I.	Wt. Lbs.
1 AM	2,000 5,000	0.11 0.21	0.13 0.30	1½
2 AM	1,000 2,000	0.22 0.40	0.35 0.57	5¼
4 AM	1,000 2,000	0.48 0.78	0.73 1.10	7½
6 AM	500 2,000	0.40 1.30	0.65 2.00	18
8 AM	500 1,500	1.00 2.30	1.45 3.80	25

For complete performance data, write for Bulletins! Specify models that interest you.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

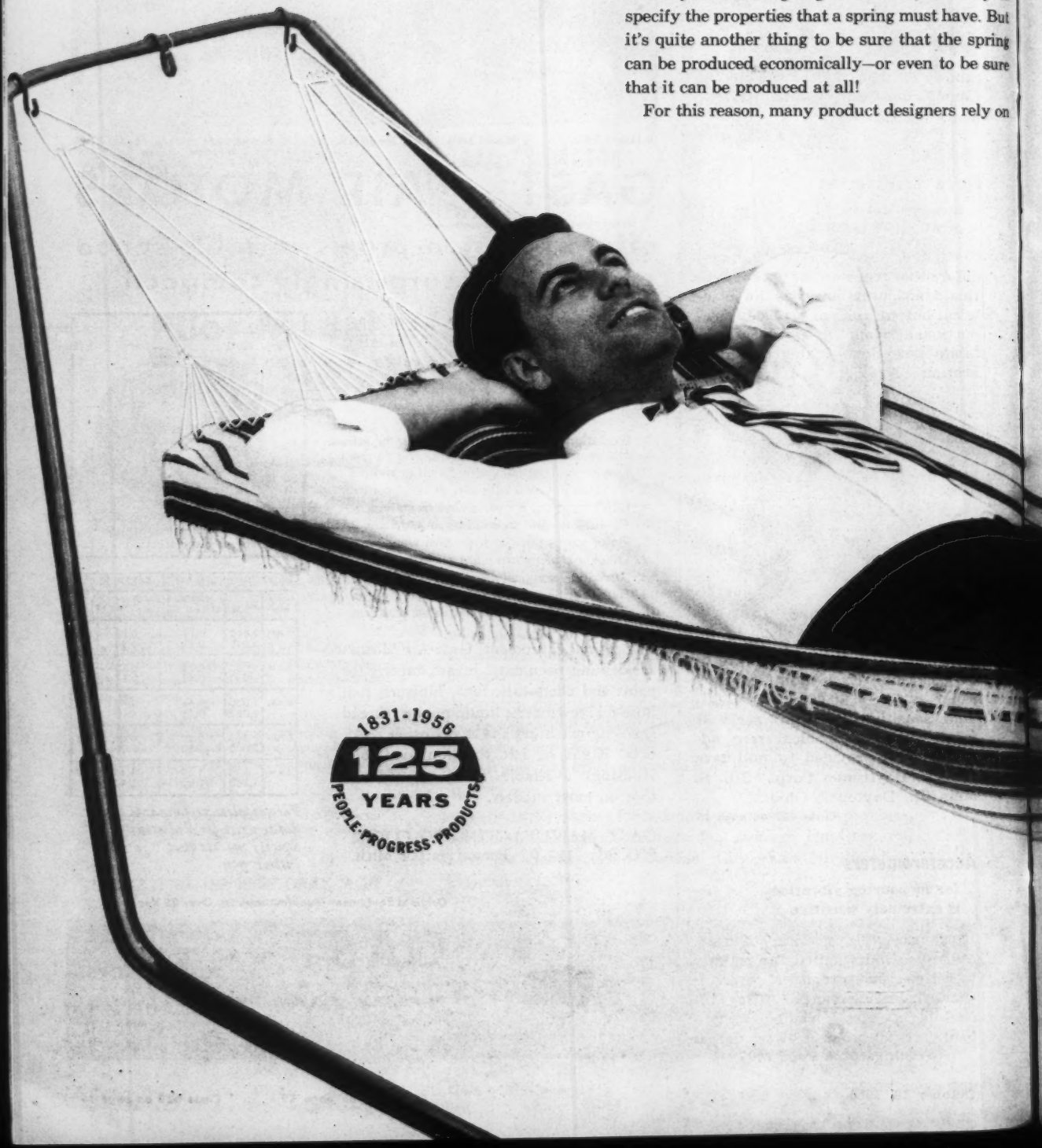
Circle 619 on page 19 *Circle 620 on page 19→*

TAKE IT EASY!...

let American

When you are designing a machine, it's easy to specify the properties that a spring must have. But it's quite another thing to be sure that the spring can be produced economically—or even to be sure that it can be produced at all!

For this reason, many product designers rely on



1831-1956
125
YEARS
PEOPLE · PROGRESS · PRODUCTS

when you have a spring problem Steel & Wire worry *for* you

specialists to help with spring design; and, believe it or not, even in these times of inflation, the specialists are free.

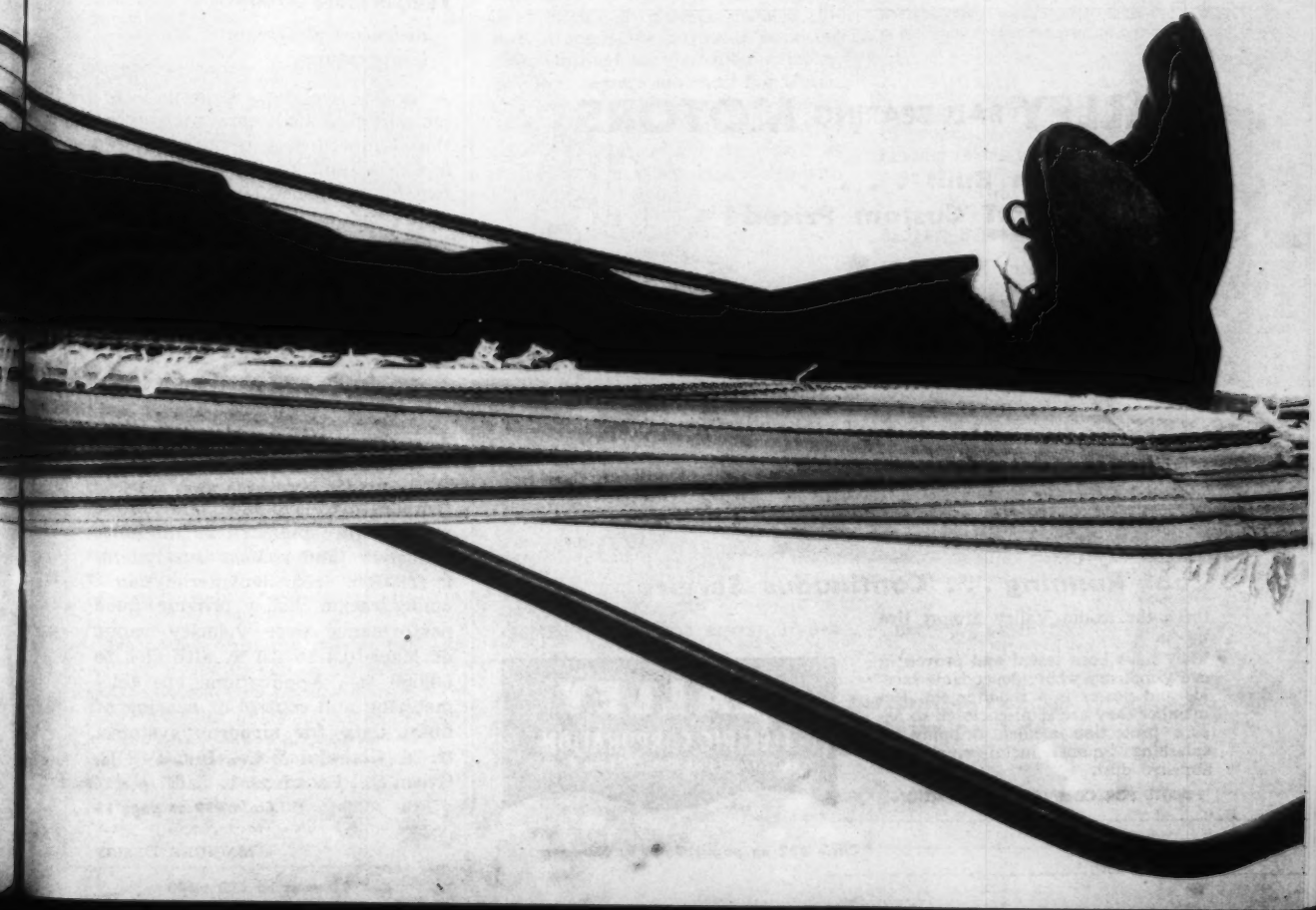
We refer, of course, to the spring engineers at American Steel & Wire. When you come down to the last phase of a new design, call in your American Steel & Wire representative. Perhaps a small specification change here, and a little design change there, will give you a *better* spring for the job, capable of mass production in high-speed machines with the obvious advantage of lower costs.

Just call your AS&W salesman.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

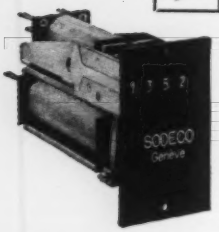
USS AMERICAN *QUALITY* SPRINGS

UNITED STATES STEEL



Designers like

✓	ELECTRIC RESET
✓	LOW POWER CONSUMPTION



OF

SODECO ELECTRIC IMPULSE COUNTERS

Sodeco Electric impulse counters can be operated in electronic circuits—their power requirements are so low. And, they offer immediate, remote electric reset. Small wonder they're the favorite of designers everywhere.

Designers also like—

SPEED Sodeco Counters Count up to 25 impulses per second

COMPACTNESS Model shown measures only 1⅜" x 2⅜" x 4⅜" and is suitable for flush mounting.

Sodeco Electric Impulse Counters are available in 4, 5 & 6 digit models, with secondary contacts, and either electrical or mechanical single-stroke toggle reset; or without reset.

Write for full information on the Sodeco line.

LANDIS & GYR, INC.
45 West 45th Street New York 36, N. Y.

Circle 621 on page 19

VALLEY BALL BEARING MOTORS

Custom Built . . .
NOT Custom Priced!

AIR COOLED

- POLYPHASE, 50 OR 60 CYCLES
- SQUIRREL CAGE INDUCTION
- HIGH TORQUE
- ½ TO 75 H.P.

Cool Running . . . Continuous Service . . .

that's the axiom Valley Motors live up to.

They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

WRITE FOR COMPLETE INFORMATION

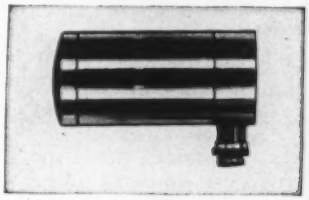
VALLEY
ELECTRIC CORPORATION
4221 Forest Park Blvd. • St. Louis 8, Mo.

Circle 622 on page 19

Engineering Equipment

(*Continued from Page* 197)

phase shift between applied acceleration and generated output voltage. Sensitivity is restricted to vector component of vibration lying along axis of the unit and is independent of frequency over entire range of operation. For constant velocity of vibration, out-



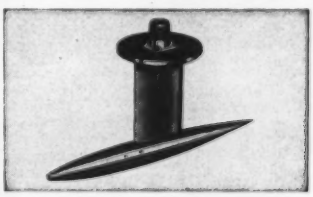
put is directly proportional to frequency, and for constant displacement output is proportional to the square of the frequency. Dynamic ranges of 0.001 to 2000 *g*, and frequency ranges of 10 to 80,000 cps are covered by three models. **Massa Laboratories Inc.**, Hingham, Mass.

Circle 488 on page 19

Temperature Probe

measures airstream temperatures

Adiabatic temperature probe is for measurement of airstream stagnation temperatures in aircraft and missile applications. Either of two fast-response temperature elements is available to provide a voltage or resistance output proportional to airstream stagnation



temperature. Housing is stainless steel, highly polished to minimize emissivity and reduce aerodynamic friction. Excellent aerodynamic configuration helps provide good performance over velocity range of Mach 0.3 to 2.0 at altitudes to 60,000 ft. Applications are telemetering and control or sensing of flight data for airborne systems. **G. M. Giannini & Co., Inc.**, 918 E. Green St., Pasadena 1, Calif.

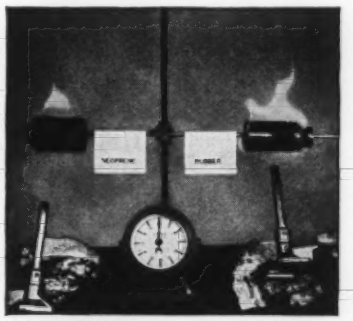
Circle 489 on page 19

DU PONT ELASTOMERS

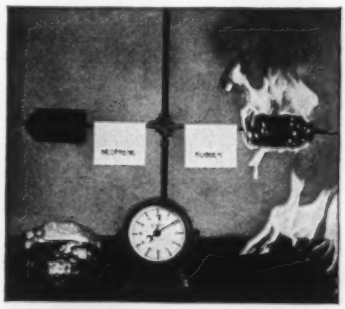
NEOPRENE - HYPALON

4 in Design

NEOPRENE ROLLERS PASS FLAME TEST!



PRINTING ROLLERS of neoprene (left) and natural rubber (right) are exposed to the flame of Bunsen burners until they ignite.



IN FIVE SECONDS after burners are removed, flame on neoprene roller is out. After 69 seconds, drippings from flaming rubber roller have ignited newspaper.

This test convinced management of the New York *Daily News* that neoprene printing rollers offer an extra measure of safety over natural rubber. Today, they flame test all rollers before they buy—and neoprene rollers are the only rollers that meet the test.

Neoprene's resistance to flame may well be useful to you as an added safety factor in your product designs. And neoprene offers resistance to abrasion, oil, heat, and chemicals as well. For all general-purpose applications, you can count on neoprene for long-term service. Clip coupon for further information.

Circle 623 on page 19

Resilient gaskets of HYPALON® unaffected by 2% ozone

Re-usable after 2 years in ozone generators

For two years now Emery Industries has been using HYPALON synthetic rubber gaskets to seal its ozone generators. The company's ozone-producing installation is the largest in the country. Its operations supervisor, Robert Peters, made this report on HYPALON. "No failures with HYPALON gaskets in two years, even though they've been exposed to 2% ozone."

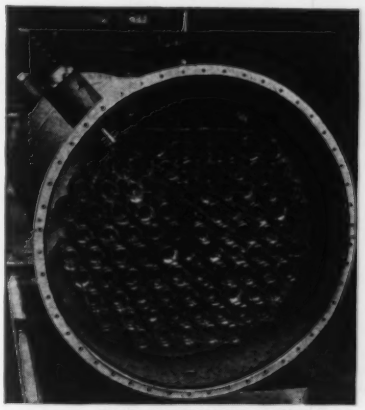


Photo courtesy Welsbach Corp., Phila., Penna.

HYPALON gasket on ozone generator showed no sign of deterioration after two years of service.

Design of the generator

The generator used by Emery Industries consists of a steel shell packed with a series of glass tubes individually encased in an electrically charged metal enclosure. A conductor carries an opposing charge through the glass tubes to make, in effect, a large electrical condenser. Dry oxygen is passed along the length of the glass tubes and converted to ozone. The generators are closed at each end by a dished head sealed with HYPALON gaskets.

HYPALON replaces plastic

Formerly, plastic gaskets were used in the generator. While unaffected by ozone, plastic gaskets had to be replaced after each maintenance checkup because they were too rigid for re-use. HYPALON gaskets, even after two years of service, retain their resilience and are still re-usable. Says the generator manufacturer, Welsbach Corporation, in Philadelphia: "We use HYPALON gaskets because they have the best over-all combination of properties of any we've found—including ozone inertness, resilience and cost."

Designing with HYPALON

HYPALON means extra-long life at lower operating costs for resilient products subject to severe service conditions. It can operate at temperatures from 250°F. to 350°F. It is particularly resistant to most oxidizing chemicals. And HYPALON resists weather and sunlight attack and can be compounded in an unlimited range of stable colors. For more information about HYPALON, clip and mail the coupon below.

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HYPALON *is a registered trademark of E.I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Please send further information and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. MD-10
Wilmington 98, Delaware

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3 CAN BE 'AUTOMATED'

WHEREVER a stud is specified, you can profitably cut production time and cost with self-tapping, self-locking Schweppe Studs. They also can replace bolts to advantage on many applications.

WHAT ARE SCHWEPPE STUDS?

They are double-ended studs made with dual thread-cutting slots at the lower end. Final threads on this end develop a positive frictional interference locking action on entering the hole.

HOW ARE THEY DRIVEN?

Schweppe Studs can be driven in an inexpensive *drilled* hole with any power stud driver. In one simple, continuous operation, they cut their own thread, drive, lock and seal.

WHAT ARE THEIR ADVANTAGES?

The *self-tapping* feature eliminates tapping time and thread inspection, tap wear and replacement, tap breakage and salvage time. The *self-locking* action of Schweppe Studs prevents loosening or backing out, even under extreme conditions.

WHAT ABOUT AUTOMATION?

Since Schweppe Studs may be located accurately from the slotted end, they can be "hopperized" for automatic feeding and driving.

• To fit many applications, Pheoll Schweppe Studs can be furnished in a broad range of metals, finishes, sizes and thread styles. Learn how you can profit . . . find out about the many advantages . . .

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Circle 624 on page 19

Stress Relief

IN HIS long experience, J. P. Henderson has often observed that designers and their intentions are not always seen clearly and appreciated by others. Here's a case in point.

Cost Conscious and Unconscious

What kind of a day was it?

It was a day like any other day to Joe Doaks, designer, as he took the cover off his drafting table and straightened up his desk.

"First," he said to himself, "I've got to call up the pattern shop, get in someone from there for a meeting with Hartley in Cost.

"This will be the second time I've had them look over that casting I've designed and the fourth time I've revised it. Last time I took a half-pound out of it. Maybe this time their cost estimates will meet that $5.50 bogey.

"Then I've got to check with Purchasing on those last quotations for die costs and piece prices on the cover gadget. It's going to be hard to decide the best overall figure. How can you amortize tool charges with the piece price, if sales can't give you a definite figure on production? Well, if they are low enough, I can use that formed steel in place of the other casting.

"There goes the phone."

Ten minutes later Joe settled at his desk with a discouraged look on his face. That new machine in Department 68B was just getting going. Now they found out that the machining job could be speeded up if the casting were chucked from the other end. Could he change the design slightly so it could be held there? Twenty drawings to change, once the formal request sheet comes through.

Joe continued his ruminations.

"After lunch I've got to attend old Bodley's meeting to consider those alternate designs for taking several dollars out of that Model A. Young Charley has an idea that might help. I'll toss it in. Otherwise I would think that job is

IF

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HOB

Circle 625 on page 19

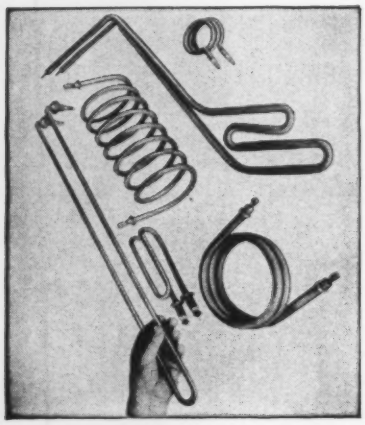
Licked by a lightweight?

Being knocked out of the running because competition is packing a powerhouse in a pint-sized contender? Maybe they are already using MPB's* such as these BALL BEARINGS ACTUAL SIZE A postcard will bring you complete data on 500 types and sizes.

Lead with your left, and write!

*MINIATURE PRECISION BEARINGS, INC.

3 Precision Park, Keene, New Hampshire



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Available in straight lengths or formed to any desired shape. Used for heating dies, molds, platens; as immersion heaters in liquids, soft metal and molten salts; or in ovens, air ducts and other air heating applications.

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☐ a copy of "101 Ways"
☐ a Sales Engineer contact me.

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Company_____
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City_____ Zone___ State_____

A-4466A

Circle 627 on page 19

Stress Relief

already stripped of its last penny. That will take most of the afternoon."

At four o'clock Joe redusted the top of his drafting table. He was just ready to draw his first line that day on that new development they were pushing him for. At that moment the sales manager was in the office of old Werner, Joe's boss. He was pacing up and down, stopping only to thump the desk.

"Darn it, Mike, you engineers are all alike. Here competition is eating into us on both the L and M models. Underselling. We can't meet their prices. Our costs are too high.

"You're all alike I tell you. Never thinking of costs when you're designing a job.

"All a design is to you people is just a pretty picture."

Oh well.

—J. P. HENDERSON

It Never Fails . . .

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DESIGNERS

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...through Chemistry

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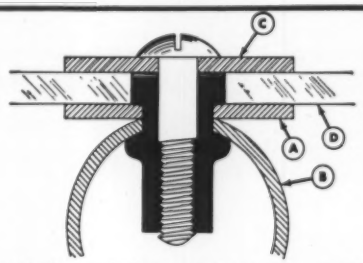
Circle 628 on page 19

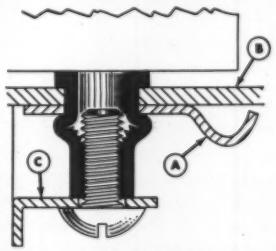
B.F. Goodrich Rivnut

cuts fastening time, saves money by doing two jobs in one operation!

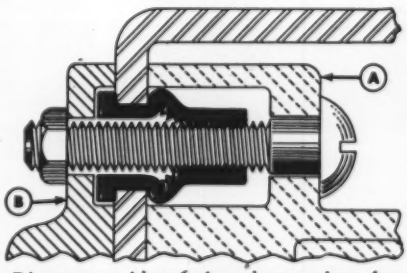
Do you have dual fastening problems like these?



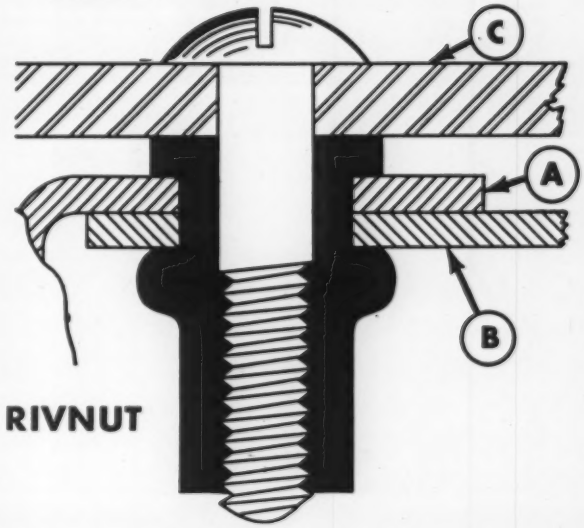
In airplane window seal, Rivnut rivets plate (A) to center post (B), provides nut plate to hold clamp strip (C). Rivnut head serves as spacer for transparent plastic sheets (D). Result: a neat, weather-tight seal!



In vaporizer assembly, Rivnut rivets upper flange (A) to casing (B), makes firm, accurate nut plate for attachment to lower flange (C). Rivnut eliminates reinforcing plate. Result: less assembly time, fewer parts, better product.



Rivnut provides 6-thread nut plate for attachment from either end—or *both*. In spotlight assembly, Rivnut replaces awkward welded stud for attaching socket (A). Plug base (B) is attached on other side. Result: fewer operations, lower assembly cost.



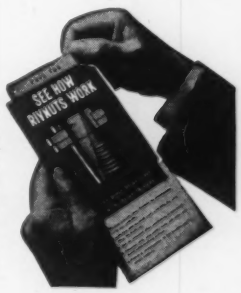
B. F. GOODRICH RIVNUTS cut costs and speed assembly because they rivet two parts together, make a firm, accurate nut plate for a third. And they do both jobs in one quick operation! Rivnuts can be installed from one side, take an attachment bolt from either end. They eliminate welding, tapping, clinching.

In the transformer assembly above, one worker fastens the metal cover (A) to the plastic sheet (B) with Rivnuts in seconds. Rivnuts then serve as mounting lugs for attaching completed transformer to mounting plate (C).

B. F. Goodrich Rivnuts have speeded up thousands of fastening jobs—can do the same for you. Write today to *B. F. Goodrich Company Tire & Equipment Division, Rivnut Sales, Akron, Ohio.*

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten WITH and TO. Explains construction, simplicity of installation. Get your free copy today by writing to: The B. F. Goodrich Company, Dept. MD-106, Akron, Ohio.



B.F. Goodrich RIVNUTS

The only one-piece blind rivet with threads

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Just press the easy-acting lever on this Quick-Reset Ratchet Counter . . . *and all 4 figures reset to zero as instantly as though you used a push-button.* This saves time and speeds work on short machine runs, inspection and many other jobs. Counter is compact . . . 2.69" long, 1.44" high, 1.29" wide. The 4 white-on-black figures are .166" high. You can order it (Series 1126) from stock right now . . . just like scores of other Veeder-Root Counters for manual, mechanical and electrical operation in every field from electronics to atomics.

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Circle 630 on page 19

THE ENGINEER'S

Library

Recent Books

Practical Solution of Torsional Vibration Problems, Volume 1, 3rd Edition. *By W. Ker Wilson; 688 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$16.00 postpaid.*

This book presents the principles and computation methods for carrying out torsional vibration investigations on many different types of installations. Frequency calculations and analysis of the characteristics of different types of oscillating systems are included along with treatments of problems concerning geared systems and systems containing distributed masses. The effective inertia method for determining natural frequencies is discussed in detail and there is a comprehensive treatment of the application of this method in cases of coupled vibration.

•

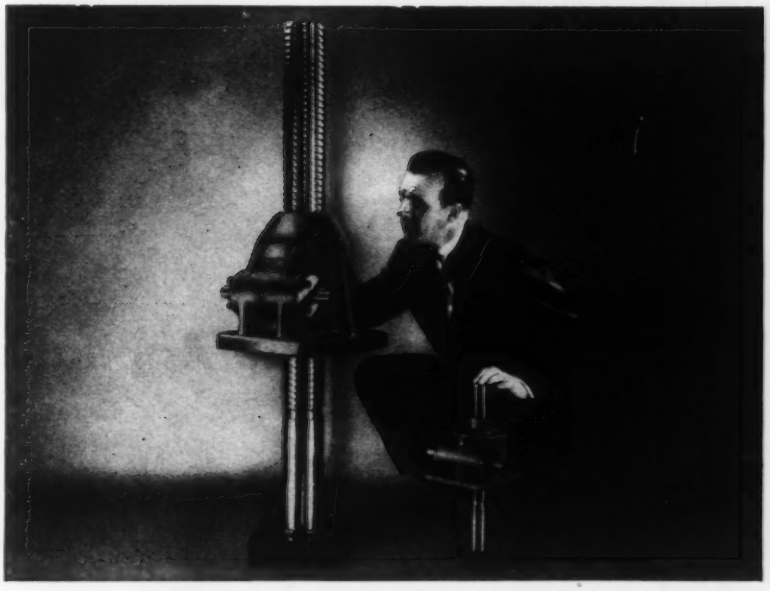
Practical Pictorial Guide to Mechanisms and Machines. *By Simon S. Palestrant; 256 pages, 6 by 9 in., clothbound; published by University Books, Inc., 404 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$4.00 postpaid.*

A vast range of mechanical devices, motions and functions are illustrated and briefly described in this unusual book. Contents have been drawn from the fields of measurements, fluids, mechanics, heat, light, sound, electricity, transportation, communications and tools.

•

The Analysis of Structures. *By Nicholas John Huff, head of Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn; 484 pages, 6*

(Continued on Page 210)

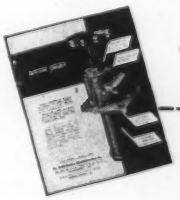


Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 6¾:1 to 27:1; turn of worm for each 1-inch raise, 10 to 40; available in either Acme or square threads. For protection against foreign matter certain models can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—adjusting welding positioners.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes. For complete specifications and detailed drawings, send for your free copy of a special brochure.



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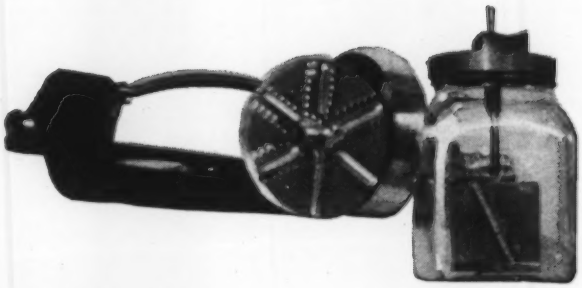
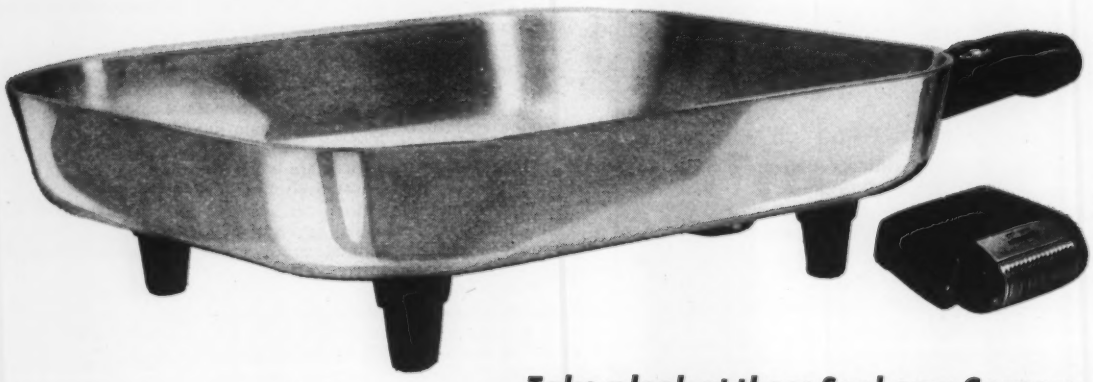
Circle 631 on page 19



Sunbeam...Home Appliances...

How Doehler-Jarvis die castings help produce high-quality products



Take a look at these Sunbeam Corporation Appliances.

Every one has features made possible by die castings.

Notice the frypan . . . Three critical requirements were successfully met by Doehler-Jarvis. (1) A large and complex Calrod element is die-cast in exact position. (2) Metal cross sections are controlled to insure even heating across the pan. (3) A die-cast seal excludes wash water from the heating element.

The frypan is a highly successful die-cast product...millions having been produced to date.

In addition, Doehler-Jarvis makes parts for the

following Sunbeam appliances sold throughout the world:

Mixmaster, Jr.	Butter Churn
Mixmaster	Clipmaster & Shearmaster
Men's Shaver	Model "S" Sprinkler
Electric Drill	Blender
Food Chopper	21" Rotary Lawn Mower
Hedge Trimmer	Egg Cooker
Slicer & Shredder	Bench Grinder

Doehler-Jarvis, possessing the world's most extensive die-casting facilities, has met Sunbeam's large-volume requirements with the desired quality and service. We are proud of our long association with the Sunbeam Corporation.

Doehler-Jarvis Engineers, if anyone, can help you convert your product ideas into best sellers through die castings. Get in touch with them—now!

Doehler-Jarvis

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Laminations shown actual size

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Catalogs on request.

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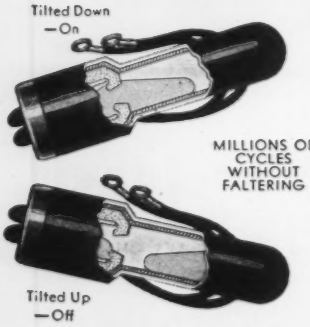
Circle 633 on page 19

Durakool Tilt Switches are the Life of your Automatic Controls



This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

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Durakool ALL-STEEL MERCURY *Switches*

Circle 634 on page 19

The Engineer's Library

(*Continued from Page 207*)

x 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from MACHINE DESIGN, $9.50 *postpaid.*

In this book, structural analysis is presented as a logical and unified theory based on a small number of first assumptions. The principle of virtual displacements is the starting point of the presentation. The volume goes on to give minimal principles of structural theory and then provides a section devoted to buckling phenomena. Among the subjects covered are: sandwich structures, stresses in reinforced monocoque cylinders, torsions of an engine mount, rigid frame analysis, limit analysis, and secondary stresses. The book concludes with a treatment of complementary energy and least work methods.

•

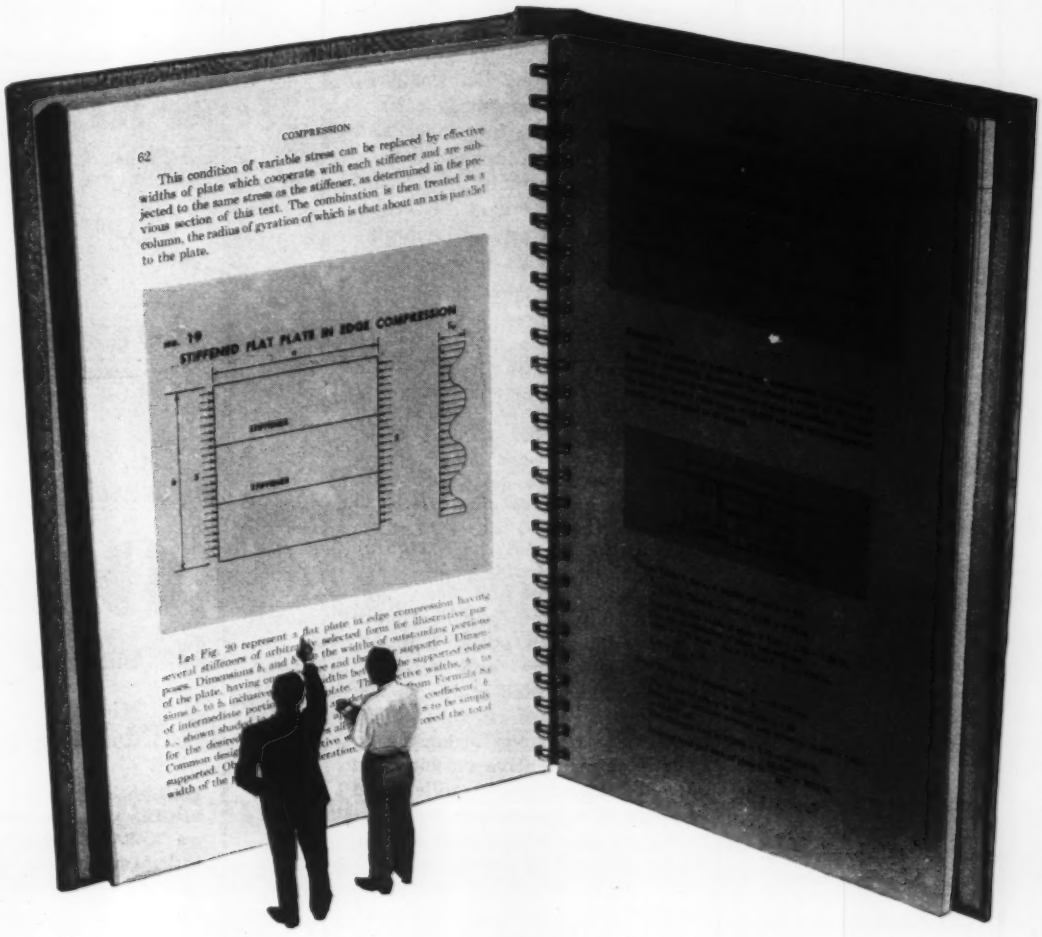
Nuclear Fuels. *By David H. Gurinsky, head of metallurgy division, and G. J. Dienes, senior physicist, both of Brookhaven National Laboratory; 333 pages, 6 by 9 in., clothbound; published by D. Van Nostrand Co. Inc., Princeton, N. J.; available from* MACHINE DESIGN, $7.50 *postpaid.*

This volume, one of the Geneva Series on the peaceful uses of atomic energy, offers a clear, compact picture of the present status of the field of nuclear fuels. Three sections cover the metallurgy of uranium and thorium, radiation effects, and solid and fluid fuels. The user is provided with the basic information necessary for fuel system design, for understanding of problems unique to reactor systems, and for a knowledge of engineering principles and applications of specific fuel systems.

•

Encyclopedia of American Associations, First Edition. *306 pages, 8½ by 11 in., clothbound; published by and available from Gale Research Co., 424 Book Tower, Detroit, Mich.;* $15.00 *per copy.*

This volume gives the name, address, chief paid official, founding date, and a description of each of thousands of American associa-


62 COMPRESSION
This condition of variable stress can be replaced by effective widths of plate which cooperate with each stiffener and are subjected to the same stress as the stiffener, as determined in the previous section of this text. The combination is then treated as a column, the radius of gyration of which is that about an axis parallel to the plate.
FIG. 19 STIFFENED FLAT PLATE IN EDGE COMPRESSION

You'll find it all here . . .

The information you need when designing for high strength steels

OUR new "Design Manual for High Strength Steels" is ready for distribution. Here are 174 pages of practical, authoritative information that you will find invaluable in designing your product for greater economy and efficiency by the sound use of high strength steels. No designer should be without it.

This excellent book covers in detail the problems of tension, compression, shear, beam stress, deformation and deflection. It fully describes the fundamental characteristics of low-alloy high strength steels, shows you how to design against corrosion, describes the application of formed sections. Complete with tables, formulas, and basic data covering this important field of design.

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USS HIGH STRENGTH STEELS

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UNITED STATES STEEL

Sam Made The PANTS TOO LONG

PRESIDENT, THE CINCINNATI GEAR CO.

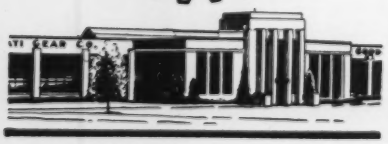
Some time ago I had a friend who decided (as I guess everyone has at some time) that the best way to get a good suit would be to buy some cloth that he particularly liked and then have the suit "made to measure" by a tailor. The purchase of the cloth presented no problem, but the selection of a tailor was another matter. He finally chose a small, inconspicuous one-man shop someone suggested to him; the poor fellow who ran it looked half starved, so he assumed he was about to get a real bargain.

After a reasonable wait, he got the suit; but it was a *terrible* fit. He went back for "alterations." It still fit poorly, but he didn't have the heart to go back again to the old man and tell him the truth — that his suit was no good. So, he gave the suit to his yard man.

The moral of this is clear — unless you're a gambler by nature, take your business to a shop that is big enough to do the job right in the first place, or to *make good* if it turns out wrong. This moral holds true whether you're buying suits or custom gears. Our reputation of nearly 50 years of virtually invariable customer satisfaction shows that we are equipped to do the job right — and if, by some chance, there *is* something wrong, we correct it to your complete satisfaction — almost quicker than you can say "Sam, you made the pants too long!"

THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
"Gears—Good Gears Only"

CINTI®



Circle 636 on page 19

The Engineer's Library

tions. Six sections list business, trade and governmental, science and engineering, educational and social welfare, health and medical, and general organizations, and chambers of commerce. A cross-indexed finding guide contains nearly 9000 listings.

♦

Mechanics of the Roller Chain Drive. *By R. C. Binder, professor of mechanical engineering, Purdue University;* 197 *pages,* 6 *by* 8½ *in., clothbound; published by Prentice-Hall Inc.,* 70 *Fifth Ave., New York* 11, *N. Y.; available from Diamond Chain Co. Inc.,* 402 *Kentucky Ave., Indianapolis* 7, *Ind. or* MACHINE DESIGN, $5.00 *postpaid.*

This book treats a roller chain drive under both static and dynamic conditions and involves theoretical and mathematical studies covering such subjects as basic force relations occurring in a chain joint, relative velocity and impact between chain roller and sprocket when meshing, and effects of sprocket tooth design. Also discussed are angular velocity variation in sprockets, joint frictional losses, vibrations of a span of chain and its path of travel between sprockets, and possible organization of power capacity relations on basis of wear, vibration, and impact.

New Standards

ASTM Standards on Light Metals and Alloys. 276 *pages,* 6 *by* 9 *in., paperbound; published by and available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.;* $3.50 *per copy.*

Standards cover specifications and methods of test for light-metal ingots, castings, die castings, bars, rods, wire, forgings, pipe and tube, sheet and plate, wrought products for electrical products, arc-welding electrodes, brazing filler-metal, and electroplating.

♦

Standards of the Hydraulic Institute, 10th Edition. 234 *pages,* 8½ *by* 11 *in., loose-leaf; published by and*

Research

with

YOU

in mind

KARAK

Research at The Ohio Carbon Company has developed "KARAK", a mixture of carbons molded under pressure and furnaced at temperatures up to 4,000° F.

(a) Will not seize or freeze to metal mating member.

(b) Theoretical melting point in excess of 6250° F.

(c) Self-lubricating in nature.

(d) Excellent dimensional stability.

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(f) Specific resistance range is from .0004 to .0020 ohms per inch cube.

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Ohio KARAK Carbon Co.

THE OHIO CARBON COMPANY
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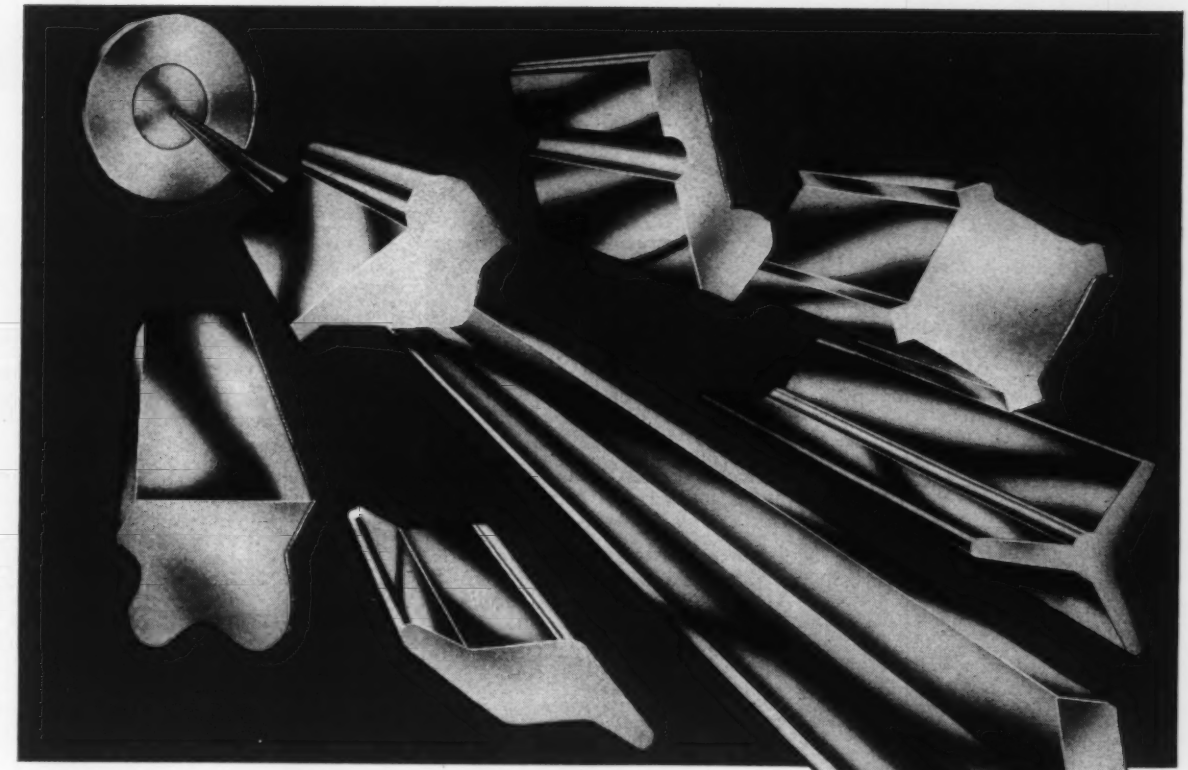
Circle 637 on page 19



J&L custom-made hot extruded cold drawn sections... boost production, cut over-all costs

Progressive industry is today utilizing J&L's Custom-Made, Hot Extruded Cold Drawn Steel Sections to:

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These sections can be extruded and cold drawn to the exact specifications of the parts you require — in any quantity you specify. Even the production of a single extrusion can be economical. Obtainable in a wide range of material grades, J&L Extruded Sections can be produced in a large variety of shape profiles — within limits of a design which can be inscribed within a two-inch circle. Many shapes that cannot be hot rolled are practical for the extrusion process.

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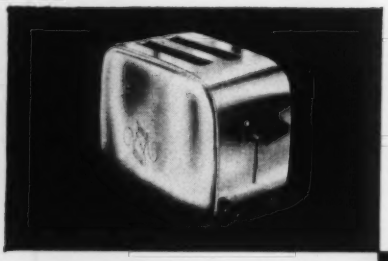
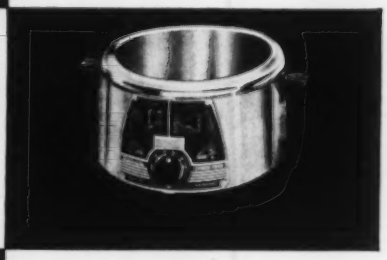
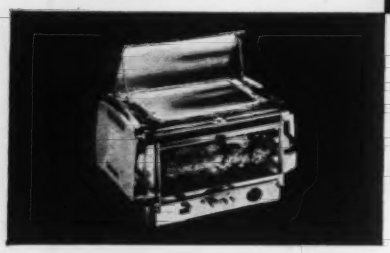


Capitol Products Co., Winsted, Conn. — Triple plated (copper-nickel-chrome) steel toaster shell eliminates costly and dangerous hand buffing. Result: increased production, fewer rejects.

Century Enterprises, Inc., New York City — Fryer wrap-around of copper steel reduces scrap factor, eliminates post-plating. Result: increased production, lower cost, fewer rejects.





Marlun Manufacturing Co., Woodside, Long Island — Chrome steel rotisserie shell eliminates post-plating operation — saves 20% in production costs.

HOW MANY REJECTS CAN YOU AFFORD?

If you're plagued by a high scrap factor due to post-plating, buffing and excessive handling of plated metal components, check the advantages of pre-plated Nickeloid Metals. These modern *finished* raw materials have brought new methods of production to the appliance industry in a wide range of cost-saving applications: toaster shells, rotisserie bodies, fryer wrap-arounds, hot plates, heating element covers and decorative trim.

Nickeloid Metals help reduce rejects because they *eliminate three production steps*—plating, cleaning, buffing; *minimize handling operations*—the plated part moves from fabrication right into assembly; and the metal, itself, is *durably, uniformly pre-plated.*

Remember, too, that in most cases Nickeloid Metals fit right into standard production techniques—require no extensive re-tooling or special handling. For severe forming operations use Nickeloid Metals protected with Mar-Not, a protective coating that peels off.

CHROME, NICKEL, COPPER OR BRASS FINISHES ON BASE METALS OF STEEL, ZINC, COPPER, BRASS AND ALUMINUM. SHEETS, COILS AND STRIPS.

More Than a Metal — It's a Method!

NICKELOID METALS
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Handy slide-chart gives specifications, finishes and typical uses for Nickeloid Metals. Contains 8 metal samples.

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Peru 8, Illinois

The Engineer's Library

available from The Hydraulic Institute, 122 E. 42nd St., New York 17, N. Y.; $4.75 per copy.

The 10th Edition has five sections. The first contains general information and a history of the Hydraulic Institute. Three following sections are devoted, respectively, to centrifugal, rotary, and reciprocating pumps. Discussion covers classification, nomenclature, application, rating, testing and instructions for installation, operation, and maintenance. The fifth section presents data on friction loss in pipes and fittings, pipe dimensions, properties of water, viscosity of liquids, and selection of materials.

Manufacturers' Publications

Super-High Strength Steels for Aircraft Applications. 31 *pages,* 8½ *by* 11 *in., paperbound and side-stapled; prepared by and available on company letterhead request from International Nickel Company Inc., 67 Wall St., New York 5, N. Y.*

This booklet is a discussion of the progress being made in higher strength alloy steels. Included is graphic data on methods and compositions which increase strength levels of the basic 4340 nickel-chromium-molybdenum alloy steel. Specific tests and applications demonstrate effects of minimum carbon content, low tempering temperatures, increased silicon content, and other variations in composition.

Government Publications

NACA Technical Series. *Each publication is 8 by 10½ in., paperbound, side-stapled; copies are available from National Advisory Committee for Aeronautics, 1924 F. St. N.W., Washington 25, D. C.*

The following Technical Notes are available:

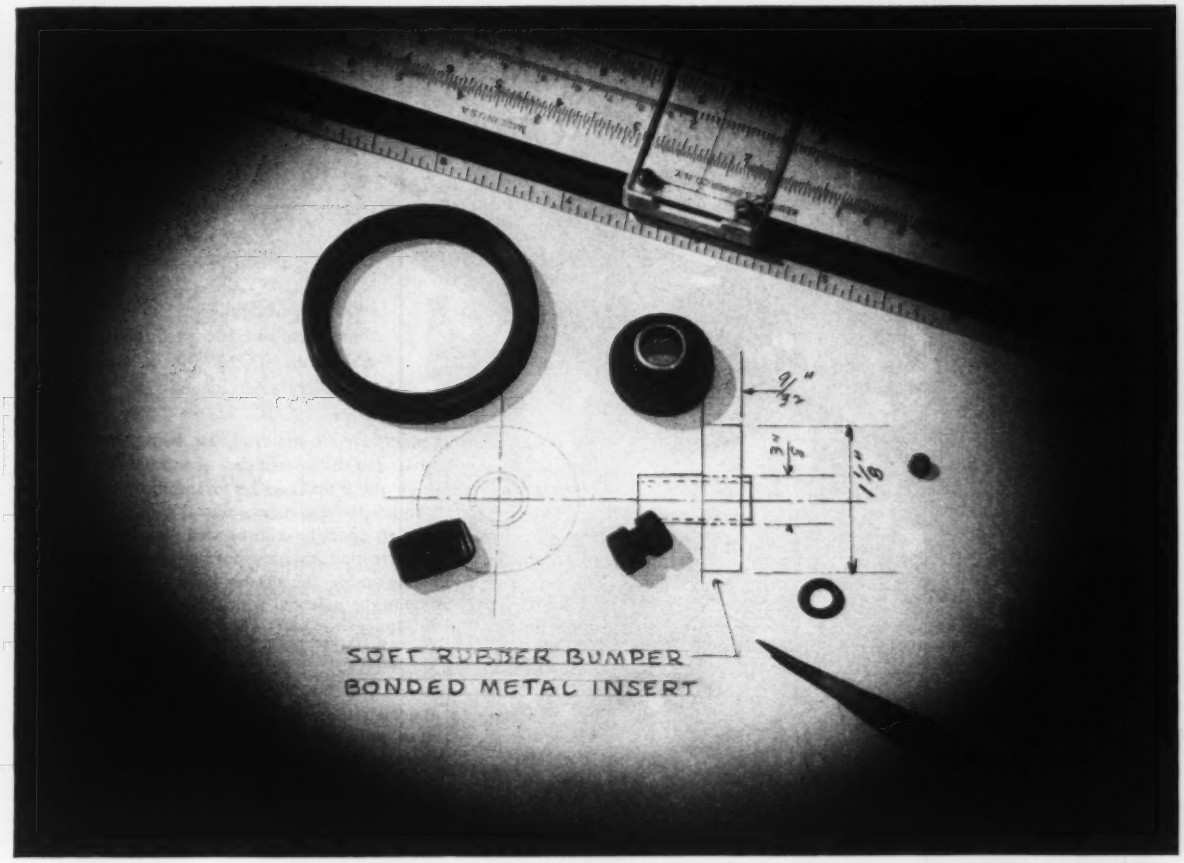
3752. **Tensile Properties of AZ31A-O Magnesium-Alloy Sheet Under Rapid-Heating and Constant-Temperature Conditions**—21 pages.

3755. **Some Observations on the Relationship Between Fatigue and Internal Friction**—42 pages.

3756. **Study of Size Effect in Sheet-Stringer Panels**—25 pages.

3757. **Torsional Instability of Hinged Flanges Stiffened by Lips and Bulbs**—12 pages.

3856. **Fatigue-Crack Propagation in Aluminum-Alloy Box Beams**—33 pages.



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PROPERTY	UNAGED	AGED 70 HOURS						
		212F Air	212F #1 Oil	212F #3 Oil	200F Water	85F Isooctane	85F Type III Fuel	85F Naphtha
Hardness	7	27	30	1	8	9	5	9
Tensile Strength	500 psi	750	600	250	200	450	400	500
Elongation	800%	550	550	750	550	750	750	800
Compression Set	50%							
Volume Change	*	*	—36%	+90%	+25%	—17%	+20%	—2%
Cold Bend	—60F OK —65F Brittle							

Dielectric Strength measured on ⅛-inch thick slab: At 10,000 volts the rubber passes 2 micro-amperes of current; at 15,000 volts the insulation breaks down. High Temperature Use—estimated limit 200F.

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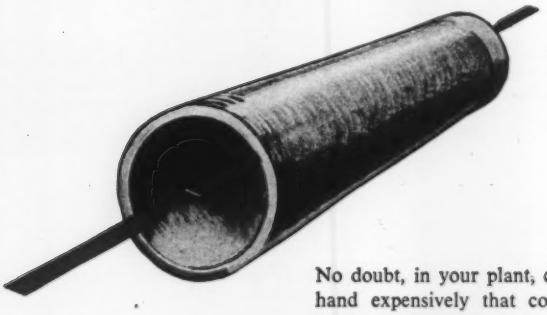
if it can be pushed through a pipe . . .



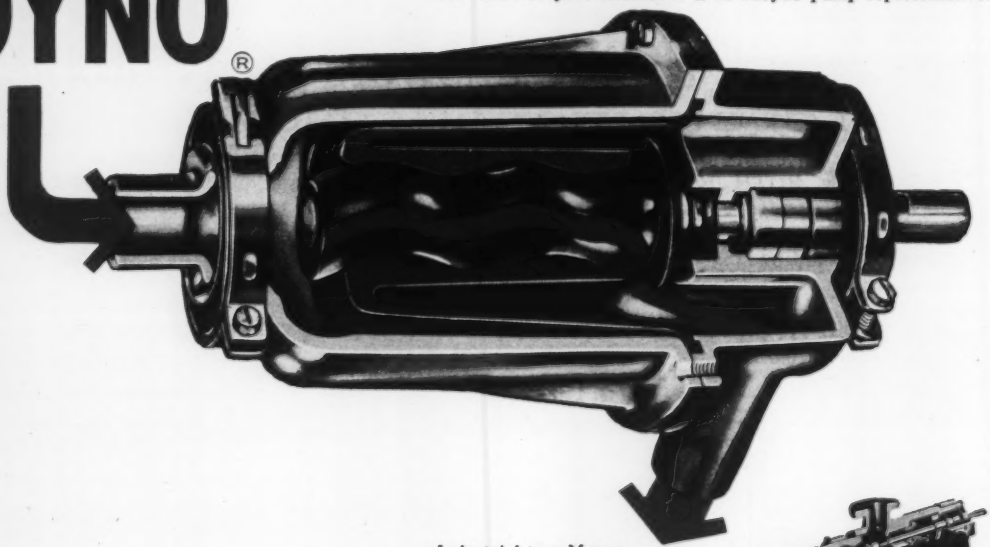
you can pump it with a

MOYNO®

No doubt, in your plant, certain materials are being moved by hand expensively that could be pumped economically by a Moyno. They pump anything that can be forced through a pipe . . . from very thin liquids to heavy, non-pourable abrasive substances . . . even materials containing suspended particles! As the illustration shows, progressing cavities, formed by the helical screw-like rotor turning inside the double-helical stator, move smoothly along, carrying the material with them . . . the cavities don't squeeze the substance . . . can't stick or gum up. Moyno pumps will not cause churning, foaming . . . won't aerate or vapor-lock!

Moynos are adaptable for a wide range of substances simply by modifying the materials the pumping elements are made of. They are available to pull up to 29" of vacuum while discharging under pressure. If you have a pumping problem, chances are a Moyno will solve it!

Write today, for Bulletin 50 MD or look in the yellow pages for name of your nearest R & M Moyno pump representative.



Industrial type Moyno . . . available to 500 gpm, pressures to 1000 psi.

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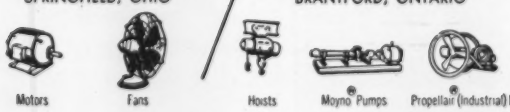


Motors | Fans | Hoists | Moyno® Pumps | Propellair® (Industrial) Fans

Circle 641 on page 19

New Machines

Materials Handling

Fork Truck: Electric-powered, stand-up, center-control fork truck, designated model R1OT, has a capacity of 10,000 lb. Design incorporates front-wheel drive, rear-wheel steer, travel speed of 4.5 mph without load, 4 mph with full load. Other features include contactor control with automatic acceleration, and four speeds forward and reverse. Direction and acceleration are controlled by a single hand control lever. Frame is of heavy-gage reinforced formed-steel plates electrically welded into a rigid box structure. *Elwell-Parker Electric Co., Cleveland.*

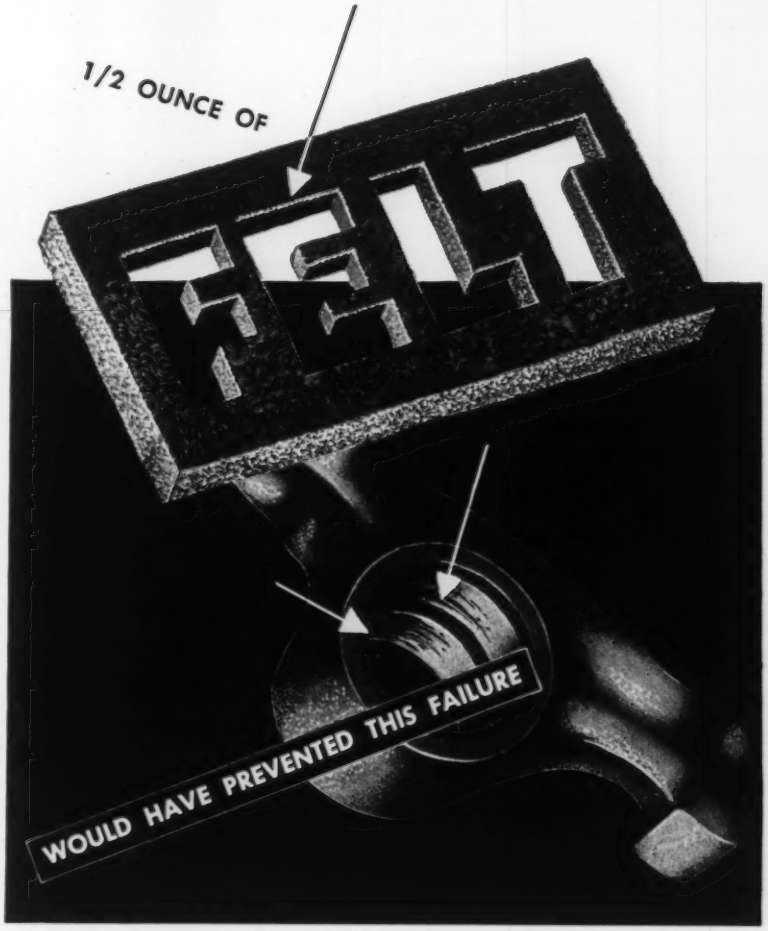
Hopper Feeder: Feedall Model 2500B hopper feeder has a 45 cu ft capacity. Range of work for rolling parts is 5 in. diam, 3/16 to 1½ in. long; for sliding parts, 3/16 to 2 in. diam up to 5 in. long. Power is furnished by a 1½-hp, 220/440-v, 3-phase motor operating through a variable speed drive. *Feedall Inc., Willoughby, O.*

Metalworking

Air Hydraulic Press: C-500 air hydraulic press with a rated capacity of 15 tons performs flanging, riveting, broaching, staking, crimping and other press operations. It has an 8¼ in. throat and delivers a 6-in. stroke at 10 cycles per minute. Other throat and stroke sizes are available. Dual hand, foot pedal or fully automatic controls are provided. *Air-Hydraulics Inc., Jackson, Mich.*

Gear Shaver: Improved Red Ring Model GCR internal shaver has a semiautomatic loader to speed loading and unloading operations. It shaves internal spur and helical gears from 3 to 12 in. pitch diam having teeth up to 4 diametral pitch and tooth face widths up to 2½ in. Workhead permits taper shaving operations to be performed on internal gears.

(*Continued on Page* 220)



The cause of a big failure is often very small.

The live fibers in Western felts resist wear, age, and weather. They never fray or ravel. As long as your machine lasts, they will be there, performing faithfully

Felt carries only clean filtered oil to all bearing surfaces. Used as a seal, felt keeps oil *in*, and dust *out* . . . permanently.

Our 57 years of experience is ready to help you. Your inquiry will place one of our Sales Engineers at your service. Write today.

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MANUFACTURERS AND CUTTERS OF WOOL FELTS

Keeping production on the move with Westinghouse pushbuttons

On Ford assembly lines, automation starts with the press of a button. From the paint line (shown), 18 different body styles are automatically guided to various trim lines. As each body passes the operator, he channels it to the proper trim line simply by pressing a button.

In textile mills, steel, paper or fabricating plants, Westinghouse pushbuttons are also on the job, guiding smooth-functioning lines of material to finished product stages. Doing it faster, better, and at a lower operating cost to you than ever before possible.

From Westinghouse you can get precisely the right operator, enclosure, whatever you need—when you need it. Complete lines of standard-duty, heavy-duty, and Oil-Tite* pushbuttons are stock items with Westinghouse.

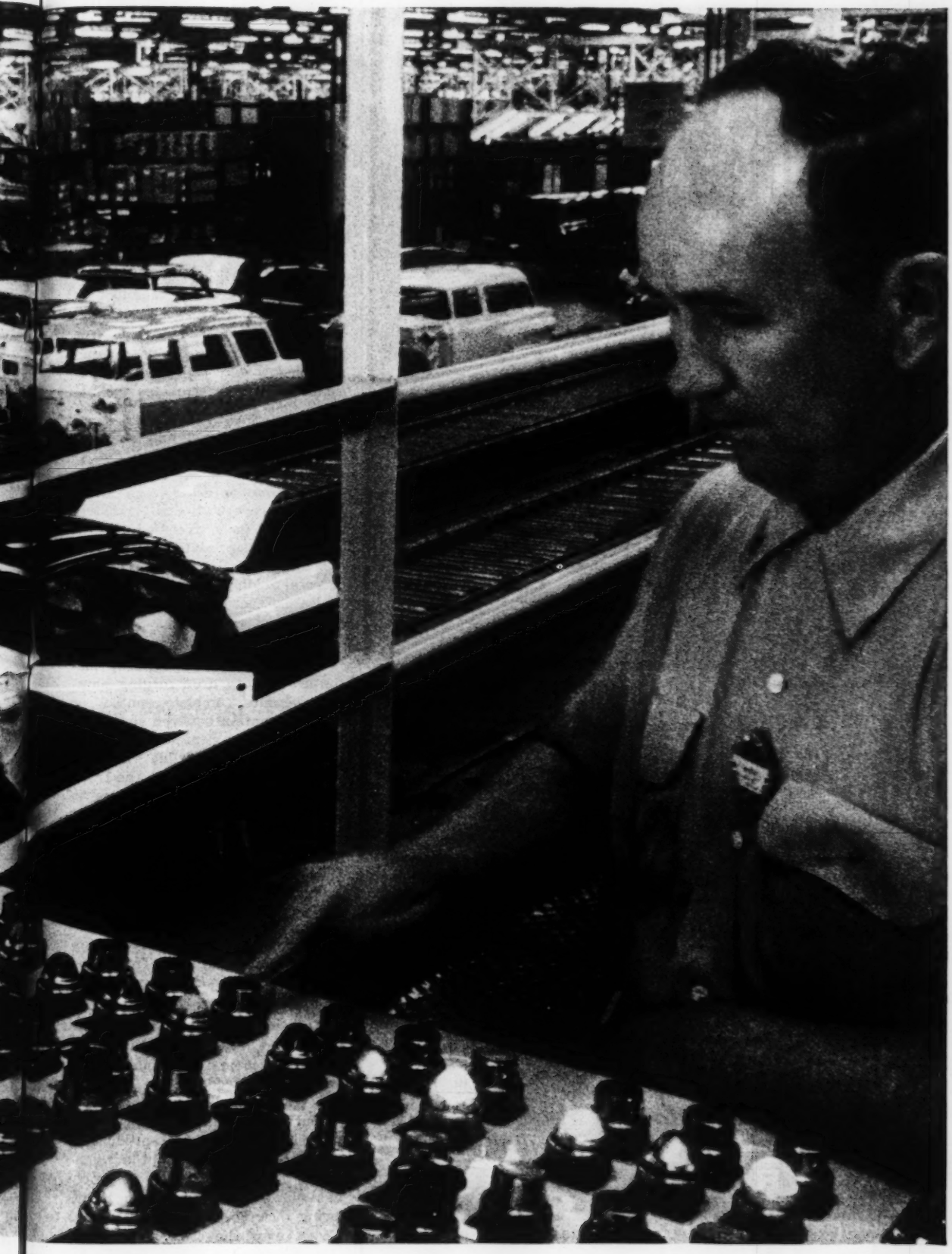
Write to Westinghouse, Box 868, Pittsburgh 30, Pa., or see your nearby Westinghouse distributor for a copy of the new *Pushbutton Guide*, B-6749.

*Trade-Mark

J-30229

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU**!*



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PROVED...

protection under high-g

SUSTAINED ACCELERATION

of the new **F-10** CLASSIFIED*

"Only All-Angl Barry Mounts gave effective isolation..."

*One of the newest and hottest fighter aircraft now flying gives its electronic equipment such a terrific slam, when afterburners are turned on or off, that sustained accelerations bottom out MIL-spec mounts — making vibration protection *nil*.

But in this same aircraft, All-Angl Barry Mounts protect the power units of Liquidometer's four fuel-gaging systems, maintaining vibration isolation under sustained accelerations up to 6g vertical and 5g horizontal.

The pilot's life — and the success of his mission — literally depend on the trueness of his fuel-gage readings! And these readings depend on the *protected reliability* of the vacuum tubes and circuitry in the power units.

- **In any mounting position**
- **Through every attitude of aircraft or missile**
- **Under sustained high-g acceleration . . .**

. . . All-Angl Barry Mounts give assured protection of reliability. Write for Data Sheet 956-01 giving details. For specific recommendations, call your Barry Sales Representative.

Barry's new Western Division, in Burbank, California, offers fast, on-the-spot design and prototype service, and production of special systems.

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BARRY B MOUNT

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New Machines

(*Continued from Page 217*)

Either conventional shaving operations with cutter reciprocation or plunge-cut shaving without cutter reciprocation can be performed. Transparent plastic insert in the cutter guard enables the operator to view the shaving operation during the cutting cycle. Change gears are provided for work spindle and cutter reciprocation drives. All electrical controls are JIC standard and mounted in a panel at the rear of the machine. Pneumatic controls are in a separate compartment in the machine base below electrical panel. *National Broach & Machine Co., Detroit.*

Arc Welder: Ac-dc and inert gas arc welder is rated 200 amp, 40 v, and has a current range of 10 to 300 amp, ac or dc. Design incorporates a case with easily removeable side panels, recessed control panel, selector switch permitting a choice of ac, dc straight, or dc reverse welding current, and magnetic contactor and removable rheostat for remote control. *Hobart Brothers Co., Troy, O.*

Forging Hammer: Rigidrop piston-lift gravity drop forging hammer permits complete control of stroke variation between short and long by varying pressure on the hammer treadle. Guide ram adjustments are made from the front and back of the machine close to floor level. Ram can be removed from the hammer at die level without jacking. Built-in inching mechanism is provided for die setups. Clamp faces are set directly opposite one another to provide positive clamping action without bending the rod. The air-operated hammer is available in sizes from 1500 through 5000 lb. *Erie Foundry Co., Erie, Pa.*

Automatic Lathes: Reedmatic production lathes are available in several sizes and combinations of mechanical feeding or hydraulic tracer slides, and can be tooled in a variety of arrangements for short-run or high-production turning, with or without automation. Two models are currently available. The C-30 has an 18 in. swing over the carriage ways and 12 in. over the cross-slide ways;

Carpenter... pioneering in improved Tool, Alloy and Stainless Steels through continuing research

TEMPERATURE: 110° F.
Permanent magnet assembly for watthour meter employing a magnetic shunt of Carpenter Temperature Compensator "30."
TEMPERATURE: -15 F.

When Precision Equipment Must Behave at Varying Temperatures... Take Advantage of *Carpenter* High Nickel Alloys!

A specially-engineered steel in Carpenter's complete line of high nickel alloys is guarding the accuracy of watthour meter performance in all kinds of weather. Its use covers a wide range of electrical equipment such as watthour meters, voltage regulators, speedometers and aircraft tachometers.

This alloy, Carpenter Temperature Compensator "30", is produced by specialists under strict quality controls. It is another example of how Carpenter's pioneering role in producing *specialty* steels to meet *special* applications works for you in your effort to build better products at a reasonable cost.

And Temperature Compensator "30" is but one of many Carpenter specialties. Other "extremely sensitive" alloys in this line respond to very weak electrical currents . . . permitting you to design smaller, lighter weight units. Still another Carpenter High Nickel Alloy assures precision product performance with practically no size change through temperature ranges up to 400°F.

Take this step for product improvement, now: Write on your company letterhead for detailed information on Carpenter Temperature Compensator, Low Expansion, High Permeability and Glass Sealing Alloys in such forms as strip, wire, bars, tubing and forging billets.

Carpenter STEEL

high nickel alloys

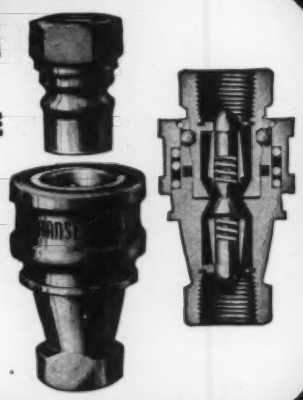
The Carpenter Steel Co., 120 W. Bern St., Reading, Pa.

Export Department: The Carpenter Steel Company, Port Washington, N. Y.—"CARSTEELCO"

HANSEN

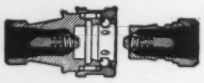
QUICK-CONNECTIVE

2-WAY SHUT-OFF COUPLINGS!



QUICK CONNECTION AND DISCONNECTION

INSTANT AUTOMATIC FLOW OR SHUT-OFF



Seals Both Ends of Line
AUTOMATICALLY INSTANTANEOUSLY

To connect a Hansen Two-Way Shut-Off Coupling, you just pull back the sleeve and push the Plug into the Socket. To disconnect, merely pull back sleeve. No tools required. Similar valves in Socket and Plug shut off both ends of line when Coupling is disconnected—practically eliminate spilling of liquid or escape of gas at instant of disconnection.

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FEMALE PIPE THREAD CONNECTIONS FROM ⅛" TO 1"

Hansen Series HK Two-Way Shut-Off Couplings are available with female pipe thread connections from ⅛" to 1" inclusive. Available in brass or steel.

Also Straight-Through and One-Way Shut-Off Couplings.

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QUICK-CONNECTIVE FLUID LINE COUPLINGS
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AIR • OIL • GREASE
HYDRAULIC FLUIDS • WATER
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SINCE 1915 — **QUICK CONNECTIVE FLUID LINE COUPLINGS**

THE HANSEN MANUFACTURING COMPANY

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New Machines

maximum input is 30 hp. The C-60 unit swings over the carriage ways 24 in. and 16 in. over the cross-slide ways; maximum input is 60 hp. Both models can be set up for chucking or between-center work. Longitudinal turning slide is mounted to a rigidly constructed top bed, to facilitate loading and unloading. Wide range of spindle speed changes is made possible by quadruple pick-off gear arrangement in the headstock. Dry-disk type clutch and brake are mounted on the main shaft. The lathes are available for either mechanical or hydraulic feeds to the turning and facing slides. Micrometer adjustment is provided for both diameter and lateral size control. Tailstock is hydraulically operated with pressure control. Tailstock quill traverses in molded plastic bearings. *Reed - Prentice Corp., Worcester, Mass.*

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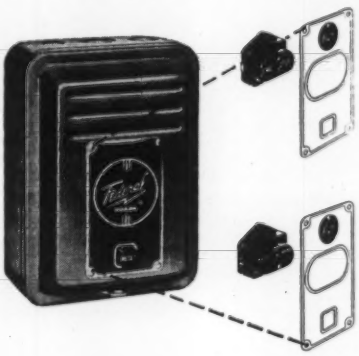

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Circle 647 on page 19

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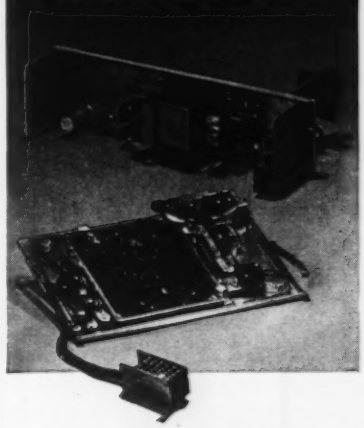

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Lead Bender: Automatic unit bends and cuts to any length coaxial leads of resistors, capacitors, diodes, coils and similar pigtail components at a rate of up to 14,000 per hour. It is designed especially to prepare coaxial lead components for insertion in printed board circuits. Easy adjustments permit quick set-ups and rapid changes in lead length and distance from angle to body. Other adjustments permit the machine to accommodate component body sizes up to 2 in. in length and 1 in. in diam, and individual leads up to $2\frac{1}{2}$ in. long. Components can be fed to a zigzag chute manually or by optional card, roll or hopper feeds. Constant-speed motor, equipped with a speed-reduction unit, provides the machine with varying production rates from zero to 14,000 parts per hour. For operation at speeds greater than 8000 parts per hour, an air-assist device can be attached to the chute to force feed the components at the desired rate. *Design Tool Corp., New York.*

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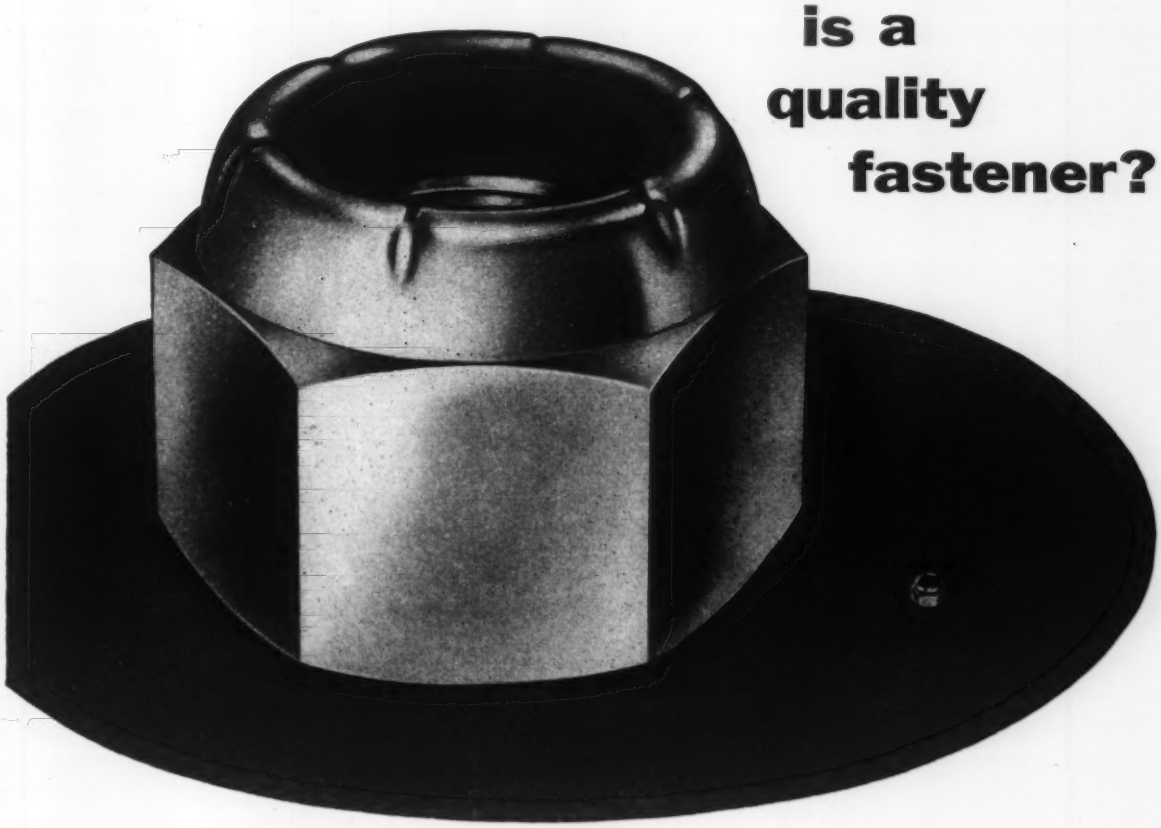

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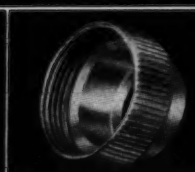
PART	 Gas Valve Fitting Nut Converted from brass to aluminum	Radio Volume Control Plug Converted from brass to aluminum	Camera Tripod Part Converted from Steel to aluminum	Nozzle Converted from brass to aluminum	Fitting Converted from brass to aluminum
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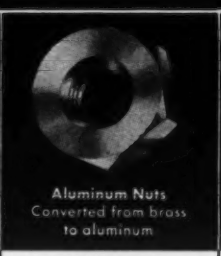

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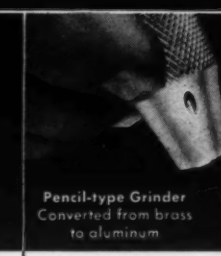
Appliance industries



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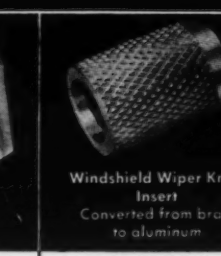

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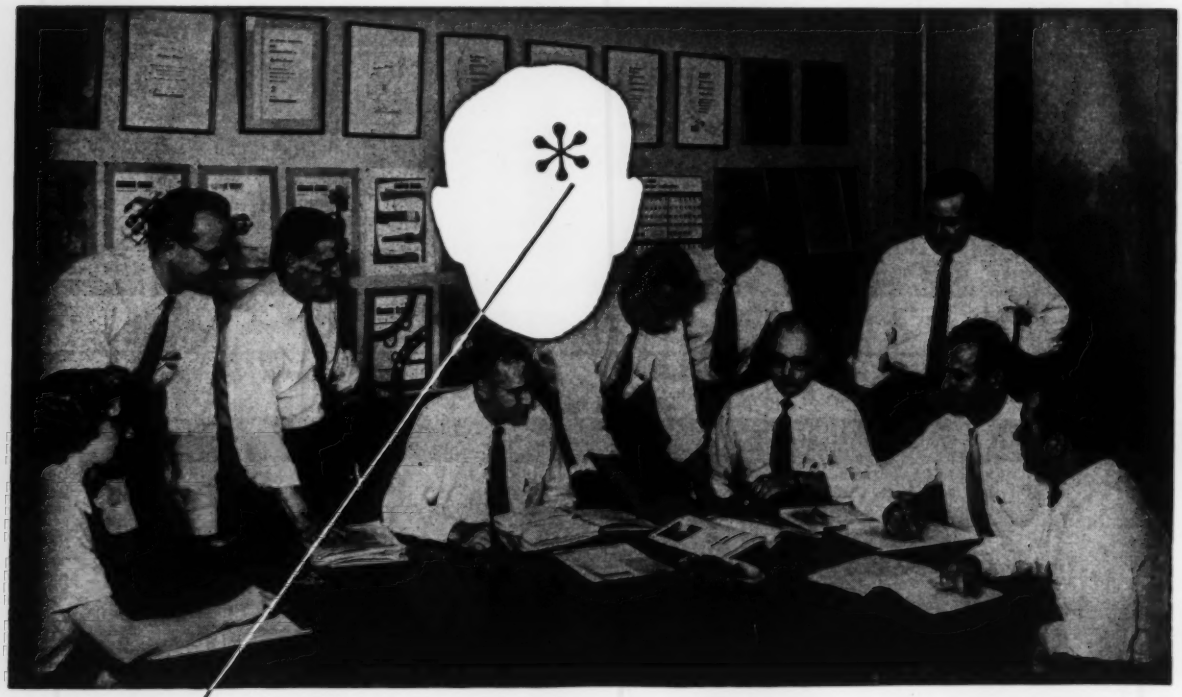

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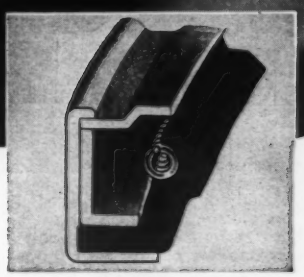

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ENGINEERING BULLETIN
ON MICRO-BEARINGS
Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH 1, NEW HAMPSHIRE

Subject: BEARING FITS AND FITTING PRACTICES

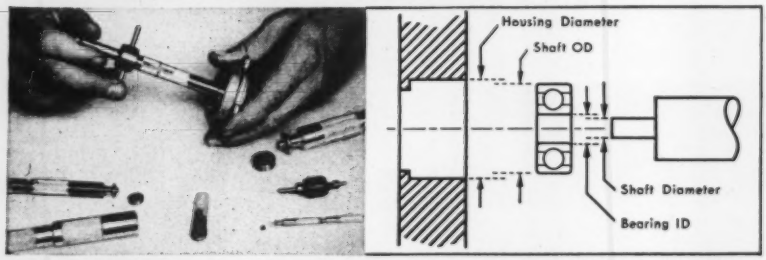

FIG. 1 *Principle factors involved in fitting Micro-Bearings Handling and fitting tools such as furnished by the Baker Co., Maplewood, Maine, enable operators to place or remove Micro-Bearings quickly, easily and help avoid damage.*

As shown in *Fig. 1*, the fitting of Micro-Bearings, like the fitting of larger ball bearings, chiefly involves the clearances between the inside diameter of the housing and the outside diameter of the bearing; the bore of the bearing and the diameter of the shaft. Obviously, proper handling and fitting is an important factor in assembling the bearing to both shaft and housing.

Arriving at workable clearances is the subject of this bulletin.

RECOMMENDED FIT

In view of the absence of standards for shaft and housing fits in assembling instrument bearings, this data sheet is based on experience of users who are heavily involved in fitting problems. For example, the use of interference fitting *tighter than line to line* is not recommended for the majority of applications.

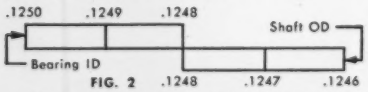

FIG. 2

The achievement of the desired fit by dimensioning is illustrated in *Fig. 2*. The bearing ID is represented by the top blocks and the shaft OD is represented by the lower blocks. Such a block diagram could also be applied to housings and bearing outside diameters. In this block diagram, it will be noted, the bearing ID is represented by a 0.0002" tolerance with a similar tolerance for the shaft. A resulting fit of line to line to .0004" loose is shown.

An interference fit *not* tighter than line to line is suggested for the following reasons:

1. *Difficulty in assembly.*
2. *Difficulty in disassembly. This is often more hazardous than the assembly operation and may result in total bearing destruction.*
3. *Reduction in radial play.*
4. *Danger of bearing ring conforming to possible poor geometry of mating shaft or housing.*

TOLERANCE DISTRIBUTION

The maximum 0.0004" loose condition shown in *Fig. 1* may be excessive in some applications. The fitting problem then resolves itself to reducing this extreme, and yet maintain the *maximum* tight fit of line to line. The looseness may be reduced by redimensioning the shaft to 0.1249/0.1247 as

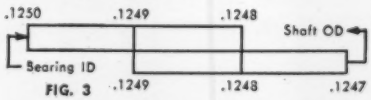

FIG. 3

shown in the block diagram, *Fig. 3*. If the frequency distributions of shaft and bearing ID sizes were statistically normal, the modal fit of all parts would be 0.0001 loose. Accordingly, an insignificant percentage of parts would be mated to the extreme values, and for practical purposes could be ignored.

With regard to bearings' outside diameters and bores, however, normality of the distribution curve *cannot* be assumed. During the grinding operation, the "most metal tendency" tends to skew the frequency distributions for bearing ID's and OD's in the direction of most metal.

In grinding and finishing shafts and housings, similarly skewed distributions occur.

Operating on a modified probability distribution of tolerance is possible if the volume of parts is sizeable. But the approximate distribution of shaft and housing sizes *must* be verified if this method is to be used.

MATERIALS and SURFACE FINISHES

The ease of assembly is also affected by materials and finishes. The following factors must be considered:

1. *The galling characteristics, hardness and ductility of the materials involved.*
2. *Finish lay patterns produced by various tools and techniques used.*
3. *RMS surface finish values achieved.*
4. *Geometry of shafts and housings as regards out-of-roundness, taper, etc.*

The possible combinations of these elements in any single application are so numerous that their gross effect can only be ascertained by trial and error, or by a detailed study of operations on individual applications.

SIZING METHODS

Close tolerance fitting may be achieved by performing supplementary sizing operations on housings or shafts by the following methods:

"Bearingizing Tools" manufactured by the Cogsdill Tool Products, Inc., have been used on both housings and shafts, and potentially yield the greatest accuracy in the shortest period of time *(Fig. 4)*. A — Shaft sizing tool operates by peening oversize shafts to proper diameter. B — Internal Bearingizer enlarges housing holes to proper diameter.

"Ball sizing" has been used with a fair degree of success on through holes. This is essentially a swaging operation utilizing hardened steel or carbide balls.

While shafts may be polished by hand this is an expensive operation and may jeopardize good shaft geometry.

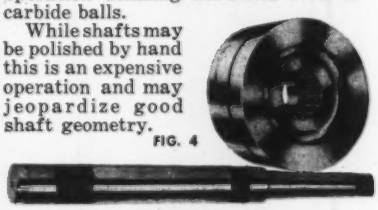

FIG. 4

CODING

Segregation of all parts into .0001 increments has been advanced by some bearing users as a solution to fitting problems. Upon request and for an additional cost, NHBB will code a given shipment to the following table.

DESCRIPTION	CODE	BORE TOLERANCE	O. D. TOLERANCE
LARGE BORE LARGE O. D.	11	+ .0000" − .0001"	+ .0000" − .0001"
LARGE BORE SMALL O. D.	12	+ .0000" − .0001"	− .0001" − .0002"
SMALL BORE LARGE O. D.	21	− .0001" − .0002"	+ .0000" − .0001"
SMALL BORE SMALL O. D.	22	− .0001" − .0002"	− .0001" − .0002"

Coding is not a general solution to the problem of fitting. Experience has shown that unless assembly techniques can cope with the existing distribution of bores and OD's within their .0002 spread, an unbalanced stock situation results in the user's plant.

Manufacturing to closer boundary dimension tolerances is not recommended at the present state of the art. It is not usually feasible to mass produce bearings to a .0001 tolerance spread. It is generally necessary to produce some two to four times the quantity of parts desired to fulfill such requirements on the basis of selection from a standard .0002 tolerance. When a user of bearings relies solely on coding of parts, a procurement and stocking problem is eventually created.

Close collaboration between the bearing manufacturer and user is necessary in planning to meet fitting problems since neither one alone has access to complete knowledge or control over all the variables involved.

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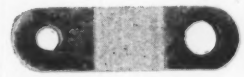
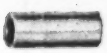


"Full-round" pitch holes . . . no sharp corners

"Full-round" pin



"Full-round" bushing

"FULL-ROUND" DESIGN eliminates stress concentration points. Heat treatment of all parts adds even greater strength and extra wear life to selected steels. Accurate control of these processes avoids brittleness, poor wear values and low tensile strengths . . . and assures uniformity.

Large pins, bushings mean ample live bearing area for long life

For long life under severe conveyor and drive conditions, Link-Belt LXS chain provides extra strength, increased wear resistance and wider application flexibility. This fabricated steel roller chain incorporates many advanced design and manufacturing refinements, resulting in superior ruggedness and accuracy.

Eliminate weak points

"Full-round" design does away with stress concentration points most frequently subject to failure . . . provides maximum live bearing area between pin, bushing and sidebars. As a result, stress is distributed evenly, increasing chain life.

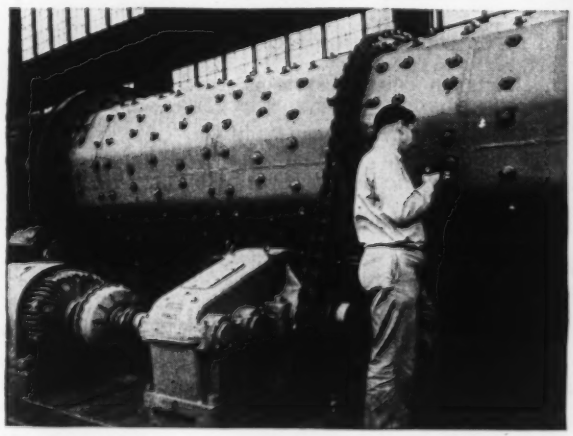
Pins and bushings are accurately sized for controlled press fit, preventing rotation in sidebars. Made from selected bar steel, sidebars are carefully machined for proper pitch hole size and for maintaining firm, tight press fit of pins and bushings. This assures close control of pitch and proper chain length after assembly.

Hardening extends life

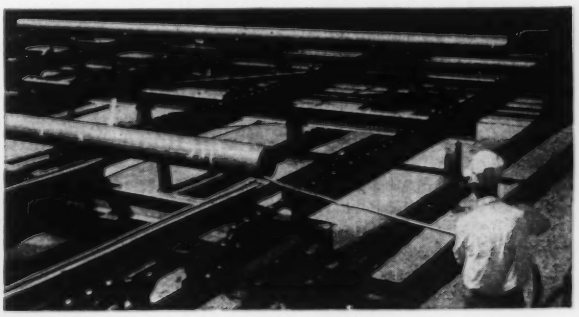
Another Link-Belt long-life extra is the controlled hardening of selected steels used in the manufacture of LXS chain. Pins, for example, are made from a tough steel, specially treated for high strength in shear and for maximum wear value. Bushings are properly hardened to shrug off shock and resist wear.

Rollers are accurately machined to assure proper operating clearances and free-rolling action. Controlled hardening gives them the necessary resiliency and durability.

LXS especially popular for exposed drives, high impacts



Link-Belt LXS chain is the long-life answer for exposed drives, abrasive and high-impact conditions. Its large, live bearing area reduces cutting action of abrasives because load is spread over a broad area.



LXS chain provides extra strength, wear-life for heavy-duty conveying

Link-Belt LXS chain has real stamina—as shown in this conveyor application for handling 1000-pound, 40-foot lengths of steel pipe. Thanks to accuracy of pitch and attachment spacing, plus close matching of multiple strands, LXS has the added strength and wear life for the extra-long conveyors so popular in today's move to mechanization.

For help with any chain problem call your nearby Link-Belt office. Send for 342-page catalog 950 covering the complete line of standard Link-Belt products for conveying and power transmission.

LINK-BELT

THE SYMBOL OF QUALITY

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,250

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ADJUSTABLE-SPEED DRIVES

. . . covers all the basic methods of adjustable speed!

by

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". . . the most comprehensive design guide on Adjustable-Speed Drives available *anywhere*"

Here, in *one* book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed. It contains the entire co-ordinated program of articles which appeared in MACHINE DESIGN on main drive and transmission types—electric-motor, slip-coupling methods, mechanical drives, and hydraulic drives.

You will find basic analyses of types and selection factors, useful listings of nomenclature and symbols, charts on control systems, tradename listings, and many other practical design details.

A *must* for your "working library". Use the handy form below and order your copies today! (Remittance enclosed with your order will speed the delivery of your copies.)

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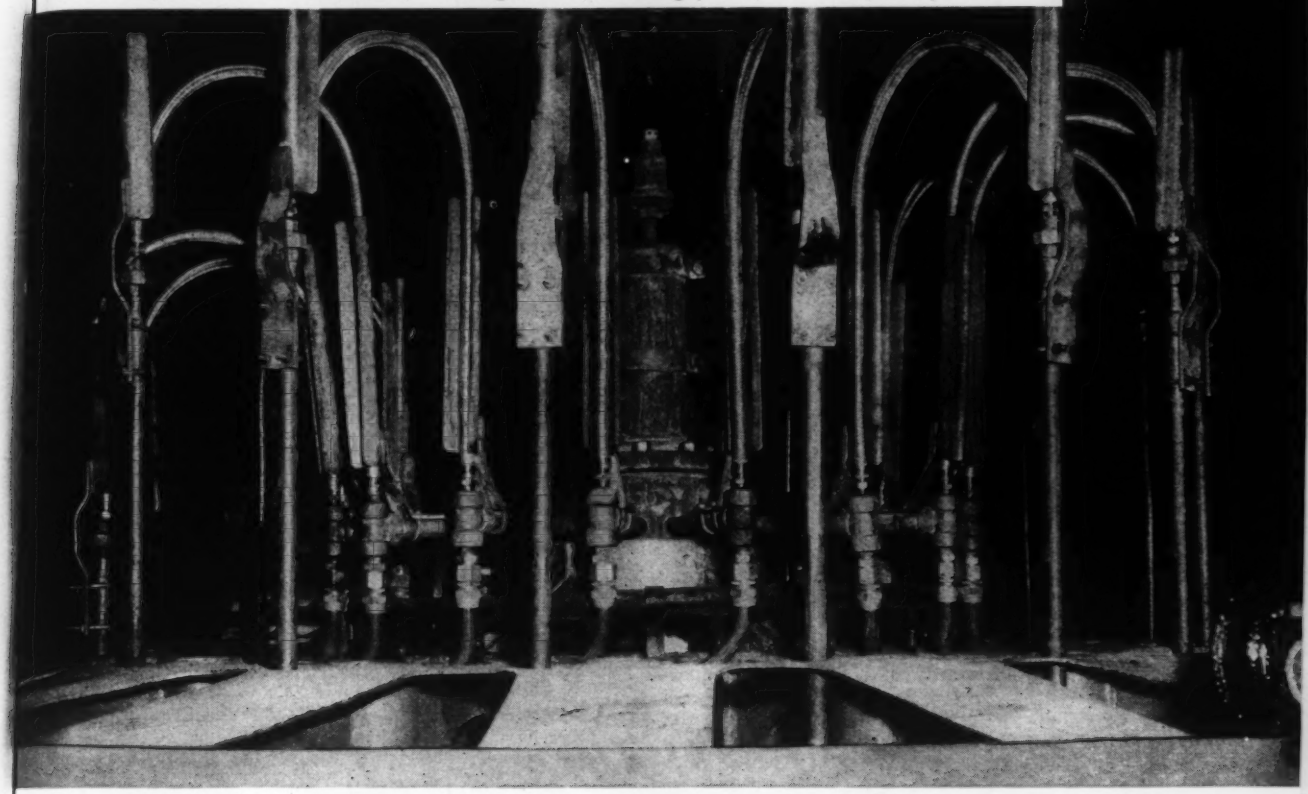
Circle 656 on page 19→

Where you convey steam

and have problems of vibration, misalignment, moving parts, or cramped space.



LIVE STEAM flows through this American stainless steel hose at 230 pounds per square inch at 390°F. Hose flexes over 100 times an hour.

You get absolutely "tight" conveyance—under high or low temperatures and pressure—with American Flexible Metal Hose!

Live steam "on the loose" can be costly . . . and dangerous. That's the problem facing the Diamond Match Company. The job: conveying live steam around a 180° bend . . . in a conveyor which must undergo continuous flexing.

Many lines were tried—and failed. American stainless steel hose was finally suggested, and is now doing the job! This is not unusual. American flexible metal hose has a long record of peak performance in the field.

It absorbs vibration and prevents its transmission to surrounding structures . . . absorbs expansion and contraction in lines due to temperature changes . . . facilitates installation, especially in cramped spaces . . . and solves the problems of misalignment.

Available in wide range of diameters in tough bronze, steel, super nickel, brass, stainless steel and other metals, American flexible metal hose delivers the very highest service hours per dollar. American furnishes flexible metal connectors to your specifications . . . ready for immediate installation.

Consult your nearby American Metal Hose representative for engineering help when planning your next job. No obligation. See American Brass Company or Anaconda in your phone book—or write: American Metal Hose Division, American Brass Company, Waterbury 20, Conn.

56178

WHEREVER CONNECTORS MUST MOVE **AMERICAN**

flexible metal hose and tubing

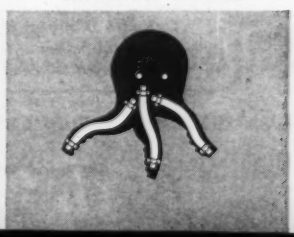
AN **ANACONDA®** PRODUCT

Contact American to solve problems of . . .

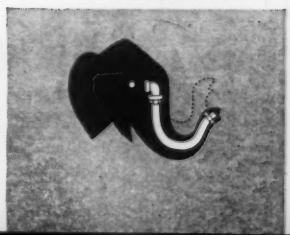
MISALIGNMENT

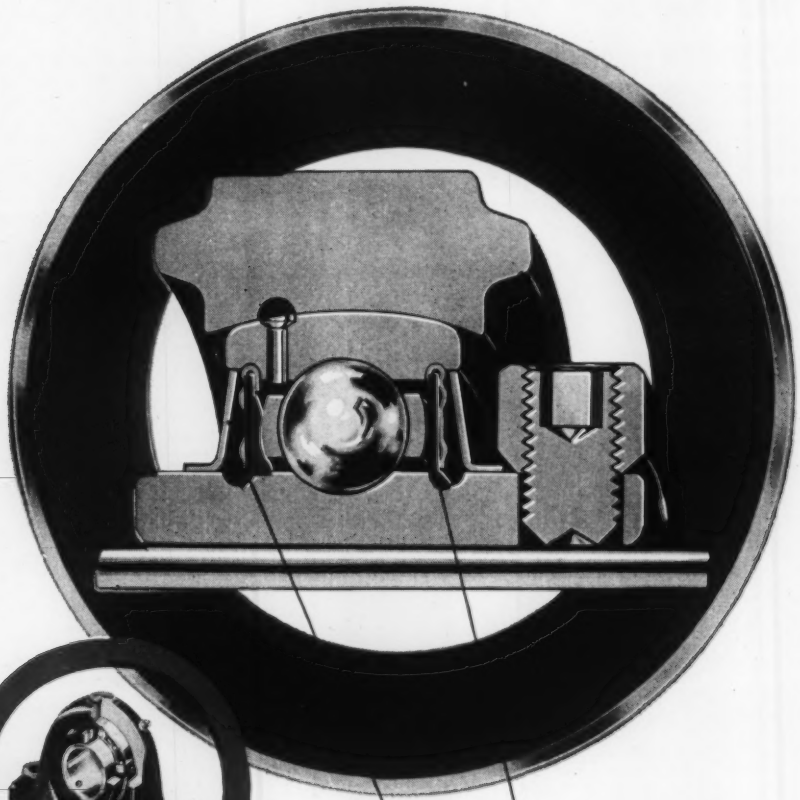
VIBRATION

CRAMPED SPACES



MOVEMENT





Type SY Unit Pillow Blocks
For set-screw mounting.
Shaft diameters: ¾" thru 4".

New Type SYH-X Unit Pillow Blocks
For eccentric lock mounting.
Shaft diameters: ¾" thru 2-7/16"

Type FY Unit Flanged Mountings
For set-screw mounting. Shaft diameters: ¾" thru 2-15/16".

New Type FY-X Unit Flanged Mountings
For eccentric lock mounting. Shaft diameters: ¾" thru 2-7/16".

THIS SKF® Red Seal

POSITIVE...PERMANENT...BEST...

Because it seals lubricant IN and keeps dirt OUT!

- Made of a Du Pont "Fairprene"
- Effective at extreme temperatures
- Unaffected by synthetic lubricants
- Lubricant can escape only when new lubricant is added
- Contact seal cannot loosen

The combination of the Red Seal and a rotating flinger assures you the best sealing arrangement available.

FEATURED IN ALL FOUR BEARING MOUNTINGS

This proven Bearing Seal is available in a complete line of unit pillow blocks and flanged housings – pre-lubricated and ready for operation – for *all* standard bolt hole spacing and center heights.

Think first of **SKF** Unit Pillow Blocks and Unit Flanged Housings when designing a new product or replacing the unit in your present equipment. 7702

SKF—EVERY TYPE—EVERY USE

SKF

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings ("Tyson")*

*Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

TEN AJAX DIHEDRAL COUPLINGS deliver 25,000 H.P. on new U E & F mill at Weirton

Close-up shows two of five pairs of Ajax Dihedral Spindle Couplings driving 23″ and 56″ x 52″ 4 high 5 stand tandem cold mill built by United Engineering & Foundry Co. for Weirton Steel Co., a Division of National Steel Corporation.

▶ The critical eyes of steel men are focused on the design, performance and output of every new mill and all its components. This new 4 high, 5 stand tandem cold mill, designed for speeds up to 7200 fpm, was built by United Engineering and Foundry Co. for the Weirton Steel Co., a Division of National Steel Corporation.

It is turning out sheet of high quality finish and maintaining close gauge tolerance.

Power is transmitted from drive stands to rolls by 10 Ajax Dihedral Spindle Couplings handling 2500 H. P. each. The uniform angular velocity of Ajax Dihedral Spindle Couplings is an important factor in producing smooth finish, uniform thickness and long roll life.

Ajax Dihedral Spindle Couplings are in operation in America's foremost steel mills. They have been proved and approved by every test of time and service. Whether you are designing, specifying, building, using or modernizing mills, it will pay you to get the facts on Ajax Dihedral Spindle Couplings.

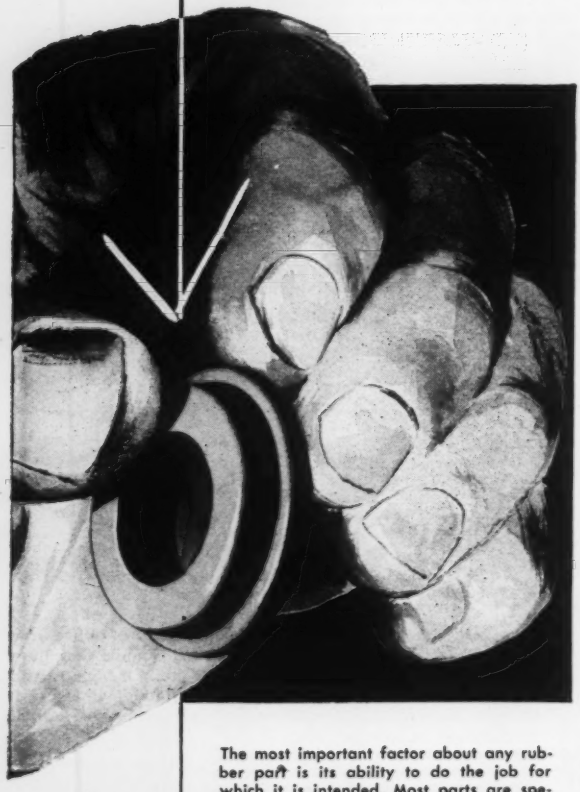
Write for Bulletin No. 58.

AJAX

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, N. Y.

Circle 658 on page 19

DOES
THIS
RUBBER PART
BELONG IN
YOUR PRODUCT?



The most important factor about any rubber part is its ability to do the job for which it is intended. Most parts are specifically engineered for the application . . . and consideration is given to elasticity, temperatures to be encountered as well as resistance to petroleum derivatives, chemicals and abrasion.

STALWART ENGINEERS have the experience and facilities to compound special rubber stocks to meet even the most unusual requirements . . . and from more than 500 different compounds already at their disposal, they can mold, extrude, die-cut, lathe-cut or mandrel-build shapes to meet any specifications.

SPECIFY STALWART RUBBER PARTS FOR THAT ONE ESSENTIAL QUALITY . . . THE ABILITY TO DO A JOB . . . BEST!

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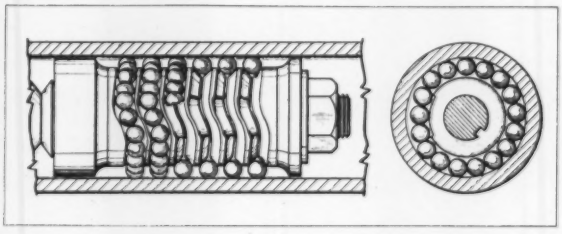
NOTEWORTHY Patents

Friction-Driven Actuator

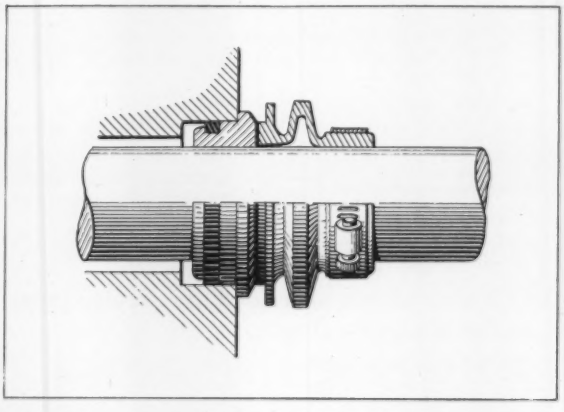
High-speed rotational motion is converted to extremely low-speed linear motion by a friction-driven actuator that uses no reduction gearing. Motion transmitting balls, rolling in helical grooves on the



driving cylinder, frictionally engage and translate the smooth-walled driven member. Multiple disks, comprising the helically grooved driving cylinder, are spring-constrained and axially adjustable to permit variation in the frictional engagement of the balls and, therefore, the load capacity of the unit. *Patent 2,756,609 assigned to Cleveland Pneumatic Tool Co. by Walter H. Hogan and Hugues Bourassa.*

Mechanical Shaft Seal

Fluid leakage around rotating shafts is prevented by a bellows-type seal which is unaffected by the corrosive action of acids, alkalies, solvents and liquified gases. Bellows, molded of a resilient thermo-



plastic, has an optically flat, antifriction wearing face which rotates against a similar face on the metallic stationary seal member. Variation of seal friction torque is provided by an adjustable clamp on the outer end of the bellows. For service with high-pressure fluids, convolutions of the bellows

now OHMITE® offers the ONLY complete line of RESISTORS to meet MIL-R-26C characteristics

Y HIGH TEMPERATURE 350C CHARACTERISTIC
HIGH INSULATION RESISTANCE

V HIGH TEMPERATURE 350C CHARACTERISTIC

AND **G**

TAB-TERMINAL TYPE Characteristics V and G

Style	Over-all Length	Diameter	*Watts	††Watts
RW-29	1¾"	½"	8	11
RW-30	1"	19/32"	8	11
RW-31	1½"	19/32"	10	14
RW-32	2"	19/32"	12	17
RW-33	3"	19/32"	18	26
RW-35	4"	29/32"	38	55
RW-36	4"	1-5/16"	54	78
RW-37	6"	1-5/16"	78	113
RW-38	8"	1-5/16"	110	159
RW-47	10½"	1-5/16"	145	210

TAB-TERMINAL TYPE Characteristic Y

Style	Over-all Length	Diameter	†Watts
RW-30	1"	19/32"	11
RW-33	3"	19/32"	26
RW-37	6"	1-5/16"	113
RW-47	10½"	1-5/16"	210

FLAT TAB-TERMINAL TYPE (Stack Mounting) Characteristics V and G

Style	Over-all Length	Width and Thickness of Core	*Watts	††Watts
RW-20	2½"		15	21
RW-21	3¼"	1-3/16"	22	31
RW-22	4¾"	x	37	53
RW-23	6"	¼"	47	68
RW-24	7¼"		63	91

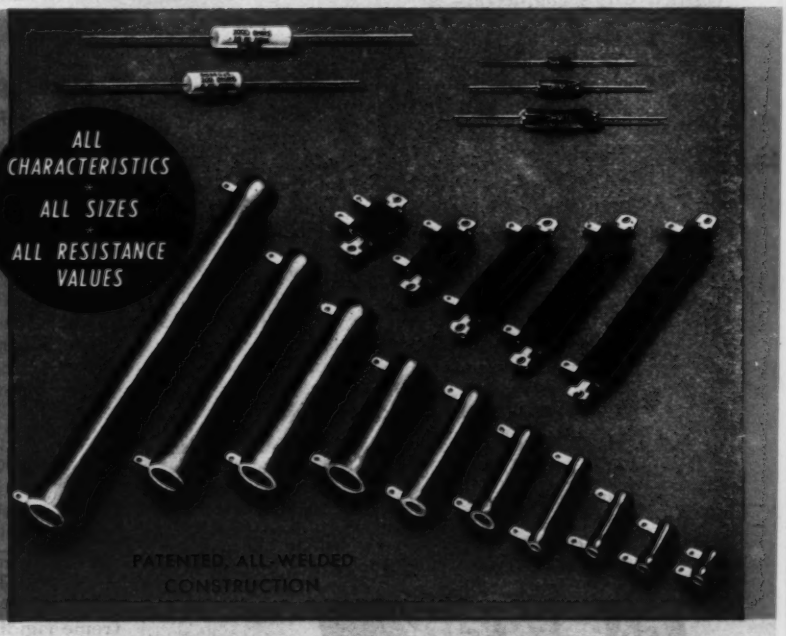
AXIAL-TERMINAL TYPE Characteristics V and G

Style	Length of Core**	Diameter	*Watts	††Watts
RW-55	1⅜"	15/32"	5	7
RW-56	2"	15/32"	10	14
RW-57	1"	5/16"	5	6.5
RW-58	1⅞"	11/32"	8	11
RW-59	½"	3/16"	2.5	3

*Watts free air MIL Characteristic "G."
†Watts free air MIL Characteristic "Y."
††Watts free air MIL Characteristic "V."
**1-½" wire leads.

Even including resistors wound with the finest wire size (.00175)

The Ohmite resistor types shown in the table above can withstand a continuous operating temperature of 350C—the high temperature requirement of MIL-R-26C, Char. "V." These resistors also meet Characteristic "G." The new Char. "Y" combines all requirements of Char. "V" and "G" plus extremely high insulation resistance at the end of the moisture-resistance test. Under all three Char., "V," "Y," and "G," Ohmite resistors have to satisfy severe moisture-resistance tests, thermal shock tests, vibration tests, and many others. The Ohmite line of wire-wound resistors is the most extensive available in the industry.



Be Right with OHMITE®

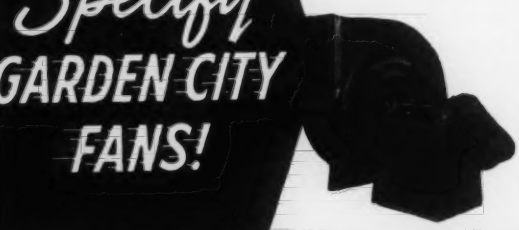
RHEOSTATS
RESISTORS
RELAYS
TAP SWITCHES
TANTALUM CAPACITORS

OHMITE MANUFACTURING COMPANY, 3618 Howard Street, Skokie, Illinois

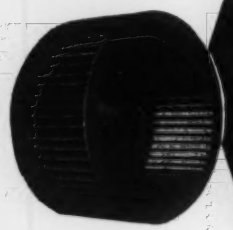
Circle 660 on page 19

Specify GARDEN CITY FANS!

Standard Steel Plate Exhauster



Design B Multiblade (Forward Curve)



There's a DEPENDABLE GARDEN CITY FAN for every need

Want efficient movement of air?

Send your O.E.M. specifications to Garden City's engineers!

- **More advanced design**

  77 years experience in making fans! Designs are simple, scientific, proven.

- **Tougher, thicker steel**

  Stamina to endure thru the years! Heavy gauge steel which resists abrasion and corrosion for a longer period of time.

- **Lower maintenance costs**

  These rugged fans stand up under roughest conditions. Sturdy construction requires minimum maintenance.

- **Remarkable performance**

  High temperature fans will move hot gases up to 1650 F. Air-cooled shaft saves dollars on your bearings-upkeep.

WRITE TODAY FOR CATALOG . . . and ask to see long list of blue chip industries using Garden City Fans

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Representatives in Principal Cities

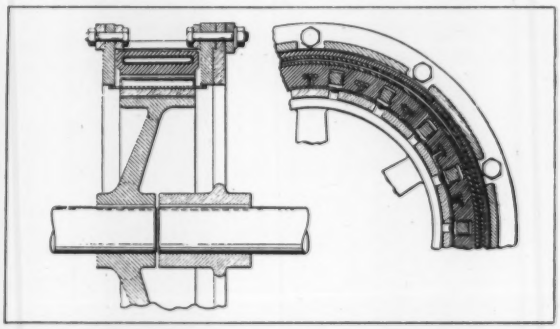
• Fans for Industry • Backward Curve • Forward Curve
• Material Handling • Radial Bladed • Small Exhaust

Noteworthy Patents

can be constrained by a close-fitting external housing. *Patent* 2,740,648 *assigned to E. I. du Pont de Nemours and Co. by Marcel Amblard.*

Frictional Brake or Clutch

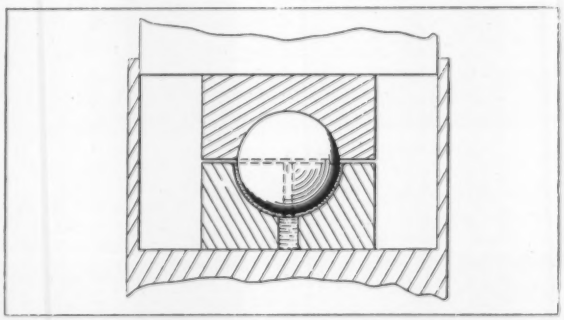
Compensation for clutch misalignment and unimpeded flow of cooling air around the expander tube is provided by a self-adjusting mounting system in a pressure-operated clutch or brake. The mounting



arrangement, which employs pivoted bars to secure the expander tube to the clutch body, eliminates overheating and other difficulties often encountered with other methods of construction. Engagement of the driving and driven shaft results when the tube is expanded by hydraulic pressure, forcing the multiple friction shoes into engagement with the outer surface of the clutch drum. *Patent* 2,723,015 *assigned to Falk Corp. by Edward J. Wellauer.*

Spin Bearing

Boundary-lubrication type spin bearing, comprising hemispherical sockets and mating steel ball, is lubricated by a thin molecular layer of fatty (oleic) acid. Lubricant reacts with the steel ball and nicked-plated



cups to form an easily sheared, self-renewing boundary surface. Characteristics of the bearing are extreme rigidity (0.5 to 1 microinch per pound of load), vibration-free operation, and a running life up to 3000 hrs. Typical applications are for supporting precision-instrument and gyroscope rotors. *Patent* 2,752,209 *assigned to North American Aviation Inc. by Joseph S. Acterman, Darwin L. Freebairn Jr. and Bert J. Sherwood.*

Here is an entirely new series of clutches combining, in a single compact unit, all of the PROVED advantages of MAXITORQ Floating Disc Clutch design with an exceptionally simple, powerful, and dependable electro-magnetic actuating mechanism.

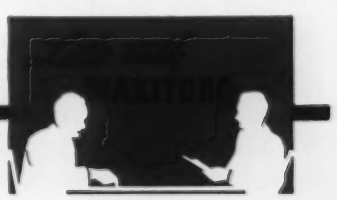
As will be seen from the illustration, the new clutches use standard proved MAXITORQ Disc-Pacs, quickly and easily replaced. The electro-magnetic unit is enclosed in a stationary housing, permitting direct wiring connection. When energized, the magnetic coil acts through an armature plate and sleeve to exert pressure on the clutch discs. Pressure, however, is maintained entirely by the magnetic flux, without mechanical contact between moving and stationary parts.

This unique design permits instant, positive engagement or disengagement, with the additional possibility of precisely controlling torque for a gradual pick-up or release of load. In addition to meeting standard clutch and brake installation requirements, MAXITORQ Electric Clutches open up new possibilities in application to fully automated equipment and for remote control.

Standard sizes, single and double types, are available for either wet or dry operation to transmit up to 788 lb. ft. of torque, operating on 110V–AC rectified to 90V–DC.

Complete details sent on request. Write Dept. MD-10.

- **PROVED** performance.
- **COMPACT** design.
- **FLOATING** neutral . . . no drag.
- **POSITIVE** engagement.
- **STATIONARY** coil . . . no brushes.
- **NO ADJUSTMENT.**
- **WET OR DRY** operation.
- **FULL** power transmission.
- **FULL** range of sizes, types.



THE CARLYLE JOHNSON MACHINE COMPANY

MANCHESTER, CONNECTICUT

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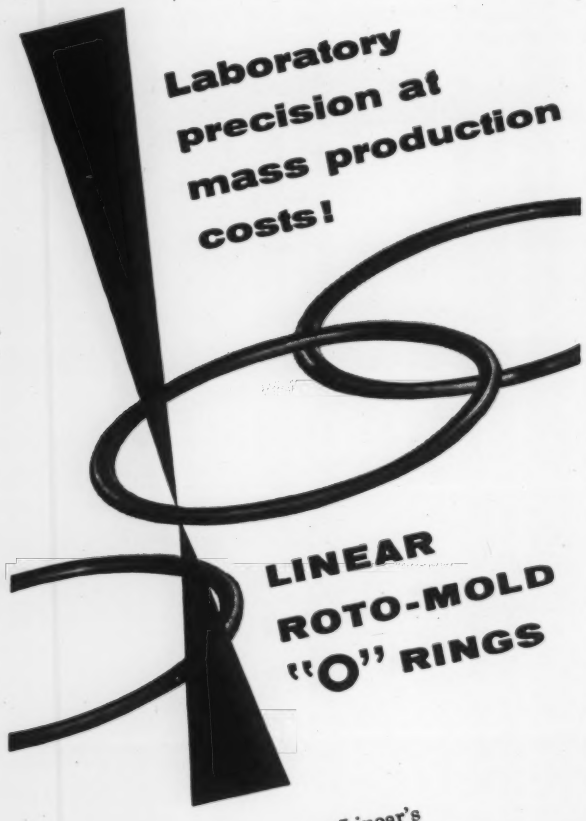


Do you have the facts on Linear's new, exclusive ROTO-MOLD process? It brings *automation* to the packing industry—makes possible fast delivery of perfectly uniform "O" Rings in any quantity!

★ Linear ROTO-MOLD "O" Rings are made with laboratory precision in single cavity molds under individually controlled pressure. Molding dies are automatically brought into microscopic alignment.

★ Every ROTO-MOLD "O" Ring is perfectly circular in cross section, with no transverse or other seams. You get precise uniformity without trimming or grinding.

Linear ROTO-MOLD "O" Rings are available now, in a variety of sizes and compounds, to meet your exacting requirements. Write, phone or wire for complete details.

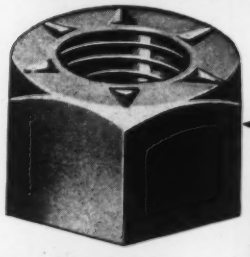
"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA.

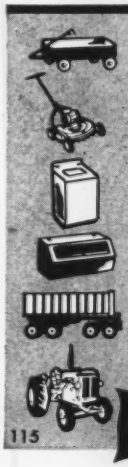
Circle 663 on page 19

SPECIFY GRIPCO LOCK NUTS



to resist stress, wear and vibration

They increase product durability at low initial cost



Simple one piece design — no inserts — no outside devices. Nothing complicated — the Gripco locking action is within the nut itself, yet you get low initial cost and low application cost with increased customer satisfaction. Speed production and lower manufacturing costs on your products now.

Send for samples and full particulars.

Gripco Products Include:

Gripco Lock Nuts • New Gripco "Clinch Nuts" Gripco Hi-Nuts • Gripco Pilot-Projection and Countersunk Weld Nuts

all with or without the famous Gripco positive locking feature. Also Standard Semi-Finish Nuts.

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GRIP NUT COMPANY

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Circle 664 on page 19

More PRACTICAL because it's Portable

Porta-Trace®

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- durable Plexiglas* top
- lifetime stainless frame
- cool fluorescent lighting

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Eliminates old fashioned, bulky tracing tables and units. Porta-Trace is ready to use in seconds! Only 1⅜" thick, it is convenient, easy to work on, and can be stored like a book when not in use. Perfect for any tracing job in drafting, layout, art, photography. And, Porta-Trace gives sufficient light to permit tracing on Bristol board! Model #1118-1, 11 x 18¼", $27.50. Available in sizes up to 24¼ x 36¼"; custom units can be built for special requirements. For complete information and price list, write today!

*Registered trademark of Rohm & Haas Co.

A. F. Gagne, Jr., Associates

340 Clinton St., Binghamton, N. Y.

Circle 665 on page 19

TRU-O-SEAL
TEFLON SEAL

STOPS PIPE THREAD LEAKS instantly!

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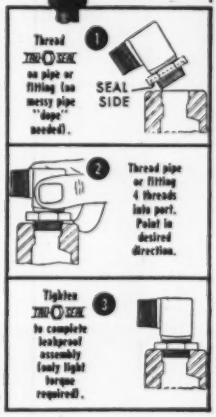
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Circle 667 on page 19

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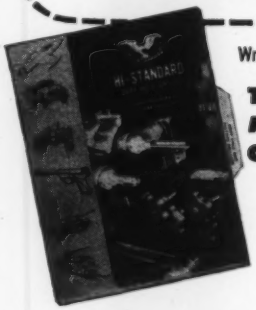

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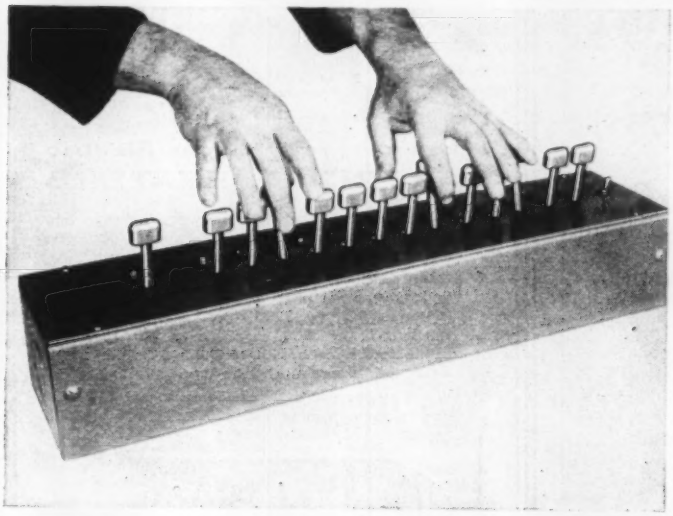

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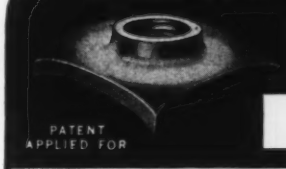

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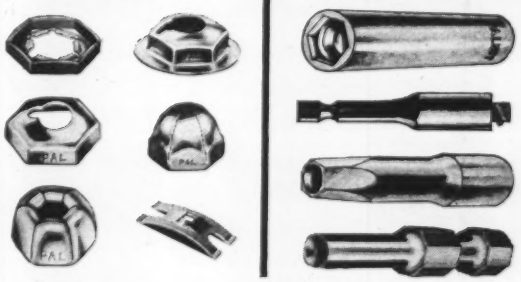

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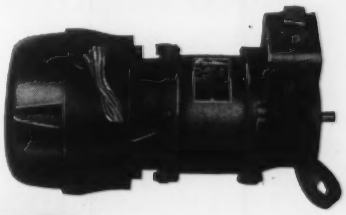

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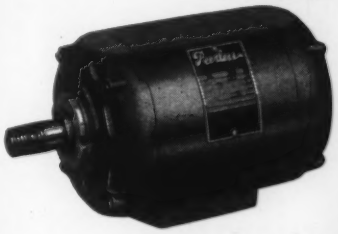

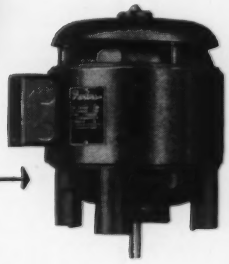

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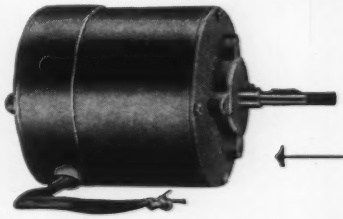

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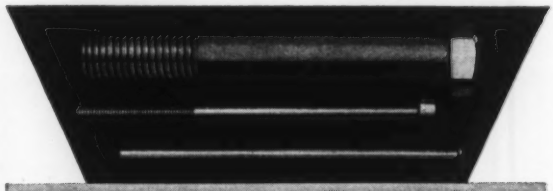

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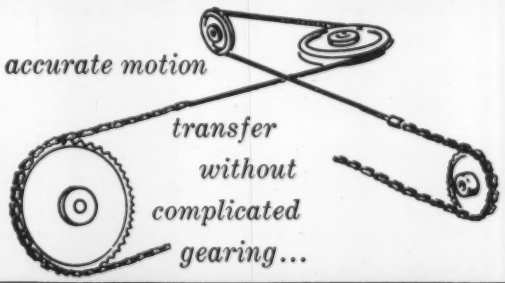

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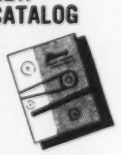

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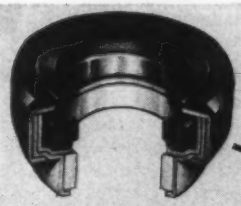
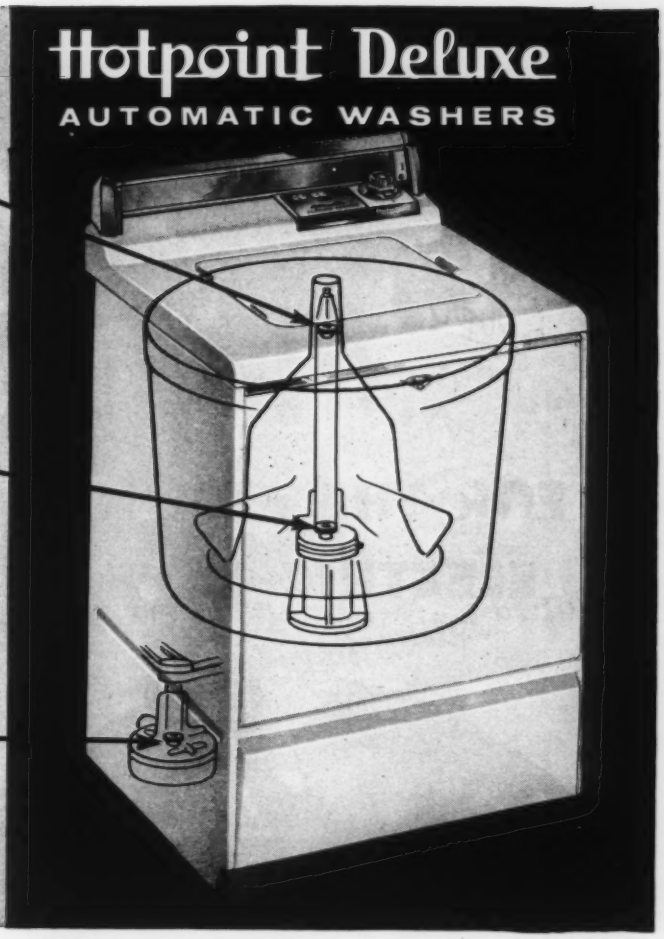


Thriftivator Shaft Seal—Victor Type K-4 oil seal, engineered with integral nylon bushing, eliminates need of conventional separate bearing and bushing.

Main Bearing Shaft Seal—Victor Type K-4 seal here provides heavy-duty dual sealing at single seal cost. Inner lip seals in lubricant; outer lip seals out foreign matter. Sealing element on outer periphery prevents leakage through housing.

Water Pump Shaft Seal—Victor Type K-3, developed especially for compact housing, assures trouble-free sealing here. Seals at O. D. and face. Garter spring is phosphorous bronze; will not corrode or rust.



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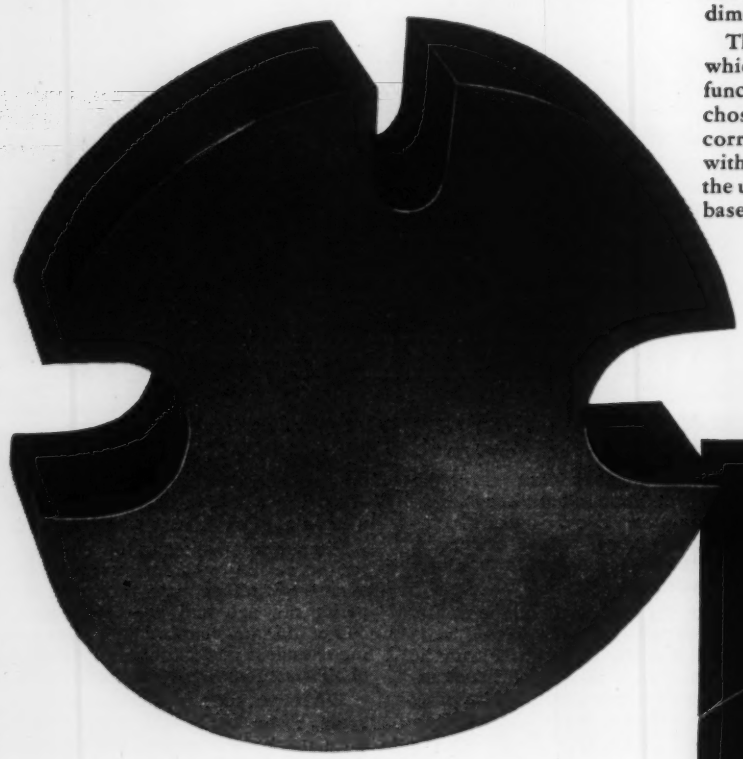
HEAVY EXTRUDED SHAPE

Over Saves 25¢ per lb.

FOR THE STRONG ELECTRIC CORP.



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Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

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Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

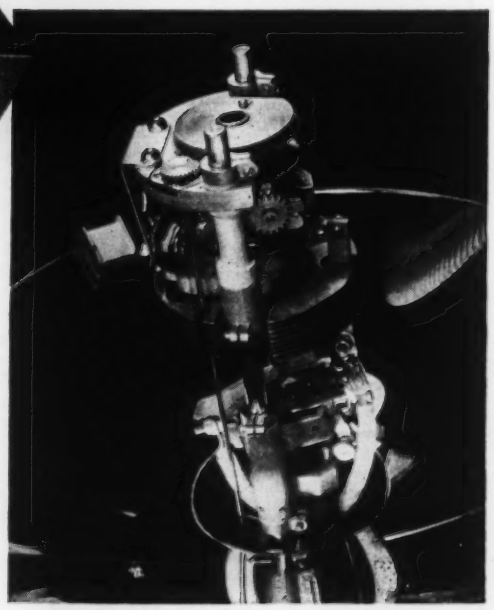
The unusual thing about this copper extruded shape is that it saves money in first cost as well as in machining time. The double economy amounts to over 25¢ per pound. The large illustration shows the shape as supplied in the form of a slug or pre-formed disc, 1 3/16" x 5". This begins as a long extrusion, from which Revere cuts the discs, and pickles them before shipping.

The customer is The Strong Electric Corp., Toledo 2, Ohio, which originally tried plate and bar, but found costs were too high. Revere Product Engineers, Methods and Production Departments collaborated with the company on the problem, and were able to develop the unusually heavy and economical shape. Strong reports a number of savings. One is that the shape is machined quickly and perfectly, with almost no rejects. This is due to the denseness and uniformity of the metal, a result of the high pressures exerted during extrusion. (Finishing operations include drilling bolt holes and cutting cooling fins.) As a secondary result of improved machining, the customer does not have to keep large inventories of metal to take care of spoilage, nor handle large quantities of scrap. Further, Revere supplies the discs in the correct thickness, eliminating a cutting-off operation for Strong. Incidentally, we are glad to supply shapes cut to dimensions, or in long lengths, as desired.

The completed part is an obturator-probe, which fulfills a control and heat dissipation function in a powerful searchlight. Copper was chosen for its ability to conduct heat and resist corrosion. Revere will be glad to collaborate with you in your search for economies through the use of extruded shapes in copper and copper-base alloys, and aluminum alloys.

Copper Extruded Shape, 1 3/16" x 5", as furnished.

Shape in place in a carbon arc searchlight mechanism.



Cleveland Worm Gear Speed Reducers were specified and installed on these cage mills by the builders of the equipment—the Raymond Division of Combustion Engineering Co., Inc., Chicago, Ill.

8 CLEVELANDS drive cage mills at L.A. sewage treatment plant

STEADY, continuous operation is all-important here. Each of the 4 double cage mills in the Hyperion Treatment Plant of the Los Angeles Sewage Disposal Division are driven by 2 Cleveland Worm Gear Reducers of 30 HP capacity. Sewage sludge, reduced to 50% moisture, drops into the cage mills with furnace gases at 1300° F. Dried sludge and steam then pass through cyclone separators.

Cleveland Worm Gearing affords exceptional advantages for practically any power job. Steel worm on bronze gear provides the best possible medium to transmit power with minimum friction and wear—reduces motor speed evenly, efficiently, and quietly. Right angle drive makes a worm gear reducer compact and rugged, with few moving parts.

Get the full Cleveland story on power transmission. Write for Catalog 400; ask for technical advice on any problem you may have. The Cleveland Worm & Gear Company, 3287 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

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